FOOD

CARNIVORE'S DILEMMA

MOUNT EVEREST: SURVIVORS OF ITS DEADLIEST DAY

NOVEMBER 2014

NATIONAL GEOGRAPHIC



REAL ZOMBIES

The Strange Science of the Living Dead



Belding's Yellowthroat *(Geothlypis beldingi)*
Size: Body length, 13.5 - 14.5 cm (5.3 - 5.7 inches) **Weight:** 13.8 - 17.7 g (0.5 - 0.6 oz) **Habitat:** Freshwater marshes with reedbeds, adjacent to marshy growth **Surviving number:** Estimated at 1,000 - 4,000

Photographed by Javier Lascurain

WILDLIFE AS CANON SEES IT

Wild for water. Belding's yellowthroat makes its home within 50 feet of water, and is rarely found more than 150 feet or so from the life-sustaining liquid. Attracted to marshes with reeds, it feeds on insects and larvae that emerge from the surrounding water. But its habitat is under enormous pressure, with marshes being drained for development and reedbeds cut or burned. When a marsh was created near a hotel district, the yellowthroat was quick to move in, but losses of marshland far outweigh gains. The waves of change may sweep the little bird away.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.



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November 2014

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On the Cover A ladybug stung by a parasitic wasp will host the wasp's egg until it hatches, then protect the wasp larva as it emerges from the ladybug and spins a cocoon. *Photo by Anand Varma*

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NG EXHIBITS

Getting food from farm to fork can be tricky. Cooking, eating, and celebrating are simpler. Visitors to the exhibit *Food: Our Global Kitchen* can explore the many ways food is made and moved around the world. Then they can taste seasonal treats, cook a virtual meal, and peek into famous figures' dining rooms. The exhibit opens October 16 at the National Geographic Museum in Washington, D.C.

FOOD



NG CHANNEL

Since prehistoric times, our appetite for meat has altered the ecosystem as well as the landscape. But at what cost? This fall—as part of a new series, *Eat: The Story of Food*—the National Geographic Channel tears into the subject of meat and how it tells the story of humankind. Check local listings for airdate.

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After the Avalanche

On the morning of April 18, a group of Sherpas and other Nepali climbers started out across the Khumbu Icefall, an unstable maze of frozen towers and crevasses that is the deadliest stretch between the base of Mount Everest and its summit. One thousand feet above them, a glacier estimated to weigh as much as 30 million pounds groaned, shifted, and crashed down the mountain.



This photo of prayer flags in the Himalaya by Aaron Huey was among nearly 4,000 prints sold to benefit Sherpa families.

Suddenly 16 people lay dead, buried under ice blocks the size of trucks. Dozens of others were injured in the worst disaster in the history of mountaineering on the world's highest peak.

In "Sorrow on the Mountain" contributing writer Chip Brown—who over the past year with photographer Aaron Huey has traveled to Sherpa villages around Everest—retells the story of the tragedy. They also assess the impact measured in the number of fatherless children—28—a canceled climbing season, and perhaps, a permanent shift in practices on Everest. "You had a workforce that was romanticized and, to some degree, exploited at the same time," Brown says of the Sherpas, who have supported climbers for more than a hundred years. "But the enormity of this accident will make things that are wrong with the system impossible to ignore."

Huey, deeply touched by the disaster, helped organize a benefit for the Sherpas, selling images by 13 photographers who had covered the Himalaya. More than $450,000 was raised.

This month's feature represents the most recent chapter in our coverage, which began on *nationalgeographic.com* the morning of the avalanche. With the help of another experienced Everest reporter, Mark Jenkins, a steady stream of stories, maps, photos, and video ultimately attracted more than a million readers. Included was an online article by Brown and Huey about Sherpa culture, which you can still read at *nationalgeographic.com/sherpas.* It was originally intended for this month's issue, but its relevance demanded immediate online publication. And, as an additional feature on our website, we explain how satellite imagery helped *National Geographic* determine the size of the fallen serac—as big as an NBA basketball court.

Our story in this issue is one we never wanted to tell, but it is an important, authoritative, and moving reflection on a tragic event whose consequences are still being felt.



Susan Goldberg, *Editor in Chief*

IN ALASKA, IT'S PREPARE OR PERISH.

LIFE BELOW ZERO°

THE THAW

NEW SEASON
TUESDAYS 9/8c
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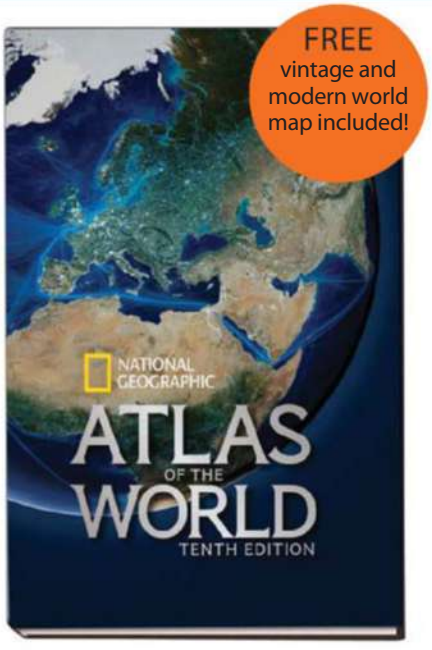
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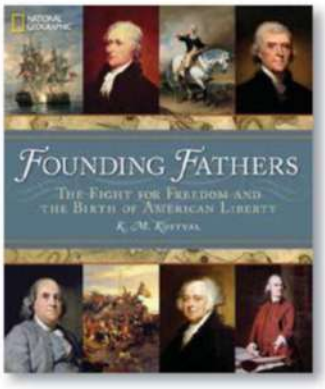
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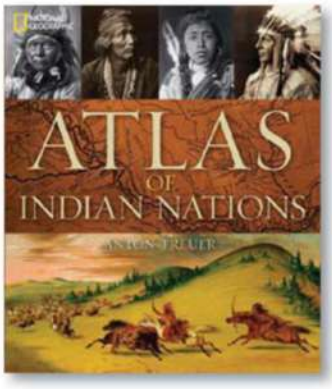
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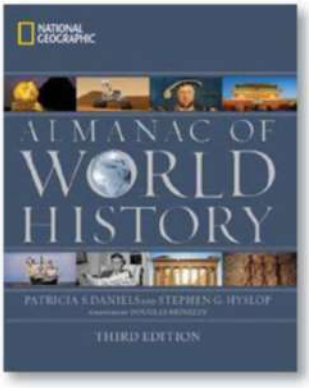
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Why I Want You to Seek the Inner Geek

Astrophysicist and author **Neil deGrasse Tyson** is director of the Hayden Planetarium in the Rose Center for Earth and Space at the American Museum of Natural History. He was also host of the National Geographic television series *Cosmos*.

CAN SCIENCE SAVE US?
I don't know if science can save us. What I do know is that the absence of science will kill us. If you look at the improvement in quality of life around the world, it is entirely brought about by advances in science and technology.

WHY IS IT CRUCIAL TO INTEREST ADULTS IN SCIENCE?
In most adults I've met, there is some ember within that carries their soul of curiosity. For some it is almost extinguished and needs to be fanned. For others it's like a pilot light. You just have to put some extra fuel there, and it ignites. We live in a time where it is possible to reignite people's inner geek—or reveal an inner geek you didn't know you had. Your inner geek is simply what empowers your curiosity about the natural world. When you see a problem, you ask, I wonder how we can solve it? rather than, I wonder how fast we can run away from it?

WHAT ADVICE DO YOU HAVE FOR THE PERSON WHO HOSTS *COSMOS* 30 YEARS FROM NOW?
It's hard to predict what problems we will have solved and what new problems will befall civilization 30 years from now. If you polled people in 1900 and asked them what they feared most for civilization, they'd say they worry about hunger and overpopulation. Starvation was a big issue because they knew what the production levels of farms were and saw the rate of population growth. What they didn't know was that we'd figure out how to farm better. They were not considering innovation. Today if you ask people, they'll say they worry about climate change or a virus. Isn't that interesting? Our risks today were undreamed of a hundred years ago.

PHOTO: REBECCA HALE, NGM STAFF

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EXPLORE

FOOD **The Future of Food** natgeofood.com



Waste Not

How much food never makes it from the market to your mouth? According to a recent U.S. Department of Agriculture report on food loss, quite a lot. In 2010, 21 percent of food at the consumer level went uneaten. USDA defines food loss as "the amount of edible food, postharvest, that is available for human consumption but is not consumed." It includes half-eaten pasta left at a café, scraps from food preparation, and sour milk a family pours down the drain. "It's lost in bits and pieces along the way," says scientist Dana Gunders. That means, she says, that small changes by consumers will add up. *—Lindsay N. Smith*



1,160 LBS.

is the annual average food loss for a U.S. family of four.

A year's worth of uneaten food, represented here in the Waldt family's New Jersey home, was later donated to a nonprofit.

A YEAR OF FOOD LOSS ACCOUNTS FOR

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PERCENTAGE OF FOOD LEFT UNCONSUMED

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0% 50% 100%

ICE CREAM **24%**

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DINNER In 2010 U.S. consumers spent more than $900 million on tomatoes that went uneaten.



BEEF **20%**

TOMATO **7%**

HOLIDAY Pumpkins are often wasted, likely because many are carved and not consumed.



PUMPKIN **69%**

EGGNOG **51%**

CHEESE Soft cheeses often spoil in weeks; hard cheeses tend to keep for months.



SWISS **50%**

PARMESAN **8%**

BEVERAGES Date labels, originally meant to indicate freshness, can mislead consumers into discarding edible food.



PRUNE JUICE **32%**

MILK **20%**

PANTRY The USDA's sugar data includes both separate portions and sugar in premade foods.

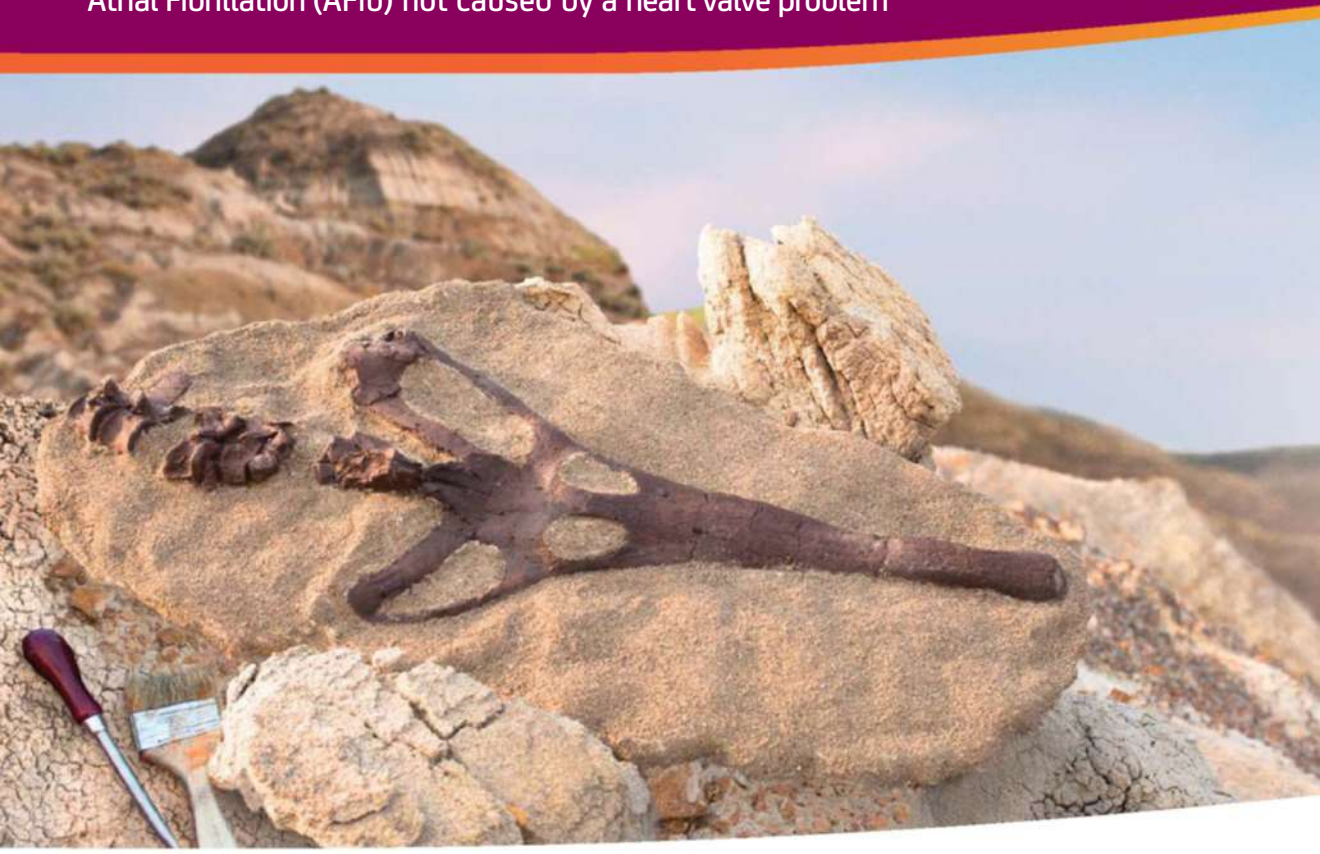


SUGAR **34%**

CANNED ASPARAGUS **2%**

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- ELIQUIS can cause bleeding, which can be serious, and rarely may lead to death.
- You may have a higher risk of bleeding if you take ELIQUIS and take other medicines that increase your risk of bleeding, such as aspirin, NSAIDs, warfarin (COUMADIN®), heparin, SSRIs or SNRIs, and other blood thinners. Tell your doctor about all medicines, vitamins and supplements you take. While taking ELIQUIS, you may bruise more easily and it may take longer than usual for any bleeding to stop.
- Get medical help right away if you have any of these signs or symptoms of bleeding:
 - unexpected bleeding, or bleeding that lasts a long time, such as unusual bleeding from the gums; nosebleeds that happen often, or menstrual or vaginal bleeding that is heavier than normal
 - bleeding that is severe or you cannot control
 - red, pink, or brown urine; red or black stools (looks like tar)
 - coughing up or vomiting blood or vomit that looks like coffee grounds
 - unexpected pain, swelling, or joint pain; headaches, feeling dizzy or weak
- ELIQUIS is not for patients with artificial heart valves.
- Spinal or epidural blood clots (hematoma). People who take ELIQUIS, and have medicine injected into their spinal and epidural area, or have a spinal puncture have a risk of forming a blood clot that can cause long-term or permanent loss of the ability to move (paralysis).

I was taking warfarin.
But ELIQUIS was a better find.

I TAKE ELIQUIS® (apixaban) FOR 3 GOOD REASONS:

1. ELIQUIS reduced the risk of stroke better than warfarin.
2. ELIQUIS had less major bleeding than warfarin.
3. Unlike warfarin, there's no routine blood testing.

ELIQUIS and other blood thinners increase the risk of bleeding which can be serious, and rarely may lead to death.

Ask your doctor if ELIQUIS is right for you.

This risk is higher if, an epidural catheter is placed in your back to give you certain medicine, you take NSAIDs or blood thinners, you have a history of difficult or repeated epidural or spinal punctures. Tell your doctor right away if you have tingling, numbness, or muscle weakness, especially in your legs and feet.

- **Before you take ELIQUIS,** tell your doctor if you have: kidney or liver problems, any other medical condition, or ever had bleeding problems. Tell your doctor if you are pregnant or breastfeeding, or plan to become pregnant or breastfeed.

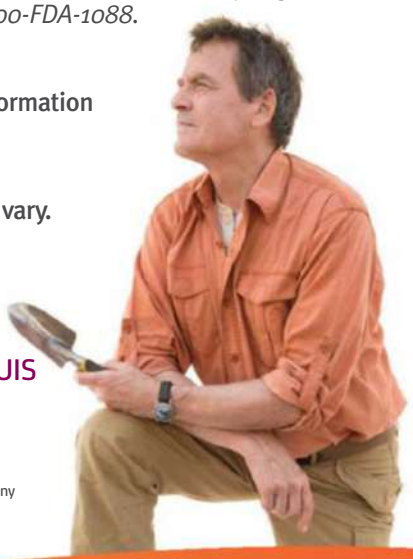
- **Do not take ELIQUIS if you** currently have certain types of abnormal bleeding or have had a serious allergic reaction to ELIQUIS. A reaction to ELIQUIS can cause hives, rash, itching, and possibly trouble breathing. Get medical help right away if you have sudden chest pain or chest tightness, have sudden swelling of your face or tongue, have trouble breathing, wheezing, or feeling dizzy or faint.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Please see additional Important Product Information on the adjacent page.

Individual results may vary.

Visit ELIQUIS.COM or call 1-855-ELIQUIS



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432US14BR01783-03-01 10/14

Eliquis®
(apixaban) tablets 5mg 2.5mg

IMPORTANT FACTS about ELIQUIS® (apixaban) tablets

(pronounced ELL eh kwiss).

What is the most important information I should know about ELIQUIS (apixaban)?

For people taking ELIQUIS for atrial fibrillation: Do not stop taking ELIQUIS without talking to the doctor who prescribed it for you. Stopping ELIQUIS increases your risk of having a stroke. ELIQUIS may need to be stopped, prior to surgery or a medical or dental procedure. Your doctor will tell you when you should stop taking ELIQUIS and when you may start taking it again. If you have to stop taking ELIQUIS, your doctor may prescribe another medicine to help prevent a blood clot from forming.

ELIQUIS can cause bleeding which can be serious, and rarely may lead to death. This is because ELIQUIS is a blood thinner medicine that reduces blood clotting.

You may have a higher risk of bleeding if you take ELIQUIS and take other medicines that increase your risk of bleeding, such as aspirin, nonsteroidal anti-inflammatory drugs (called NSAIDs), warfarin (COUMADIN®), heparin, selective serotonin reuptake inhibitors (SSRIs) or serotonin norepinephrine reuptake inhibitors (SNRIs), and other medicines to help prevent or treat blood clots.

Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.

While taking ELIQUIS:

- you may bruise more easily
- it may take longer than usual for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding when taking ELIQUIS:

- unexpected bleeding, or bleeding that lasts a long time, such as:
 - unusual bleeding from the gums
 - nosebleeds that happen often
 - menstrual bleeding or vaginal bleeding that is heavier than normal
- bleeding that is severe or you cannot control
- red, pink, or brown urine
- red or black stools (looks like tar)
- cough up blood or blood clots
- vomit blood or your vomit looks like coffee grounds
- unexpected pain, swelling, or joint pain
- headaches, feeling dizzy or weak

ELIQUIS (apixaban) is not for patients with artificial heart valves.

Spinal or epidural blood clots or bleeding (hematoma). People who take a blood thinner medicine (anticoagulant) like ELIQUIS, and have medicine injected into their spinal and epidural area, or have a spinal puncture have a risk of forming a blood clot that can cause long-term or permanent loss of the ability to move (paralysis). Your risk of developing a spinal or epidural blood clot is higher if:

- a thin tube called an epidural catheter is placed in your back to give you certain medicine
- you take NSAIDs or a medicine to prevent blood from clotting
- you have a history of difficult or repeated epidural or spinal punctures
- you have a history of problems with your spine or have had surgery on your spine

If you take ELIQUIS and receive spinal anesthesia or have a spinal puncture, your doctor should watch you closely for symptoms of spinal or epidural blood clots or bleeding. Tell your doctor right away if you have tingling, numbness, or muscle weakness, especially in your legs and feet.

What is ELIQUIS?

ELIQUIS is a prescription medicine used to:

- reduce the risk of stroke and blood clots in people who have atrial fibrillation.

)

This independent, non-profit organization provides assistance to qualifying patients with financial hardship who generally have no prescription insurance. Contact 1-800-736-0003 or visit www.bmspaf.org for more information.

- reduce the risk of forming a blood clot in the legs and lungs of people who have just had hip or knee replacement surgery.

It is not known if ELIQUIS is safe and effective in children.

Who should not take ELIQUIS (apixaban)?

Do not take ELIQUIS if you:

- currently have certain types of abnormal bleeding
- have had a serious allergic reaction to ELIQUIS. Ask your doctor if you are not sure

What should I tell my doctor before taking ELIQUIS?

Before you take ELIQUIS, tell your doctor if you:

- have kidney or liver problems
- have any other medical condition
- have ever had bleeding problems
- are pregnant or plan to become pregnant. It is not known if ELIQUIS will harm your unborn baby
- are breastfeeding or plan to breastfeed. It is not known if ELIQUIS passes into your breast milk. You and your doctor should decide if you will take ELIQUIS or breastfeed. You should not do both

Tell all of your doctors and dentists that you are taking ELIQUIS. They should talk to the doctor who prescribed ELIQUIS for you, before you have **any** surgery, medical or dental procedure. **Tell your doctor about all the medicines you take, including** prescription and over-the-counter medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way ELIQUIS works. Certain medicines may increase your risk of bleeding or stroke when taken with ELIQUIS.

How should I take ELIQUIS?

Take ELIQUIS exactly as prescribed by your doctor. Take ELIQUIS twice every day with or without food, and do not change your dose or stop taking it unless your doctor tells you to. If you miss a dose of ELIQUIS, take it as soon as you remember, and do not take more than one dose at the same time. **Do not run out of ELIQUIS.**

Refill your prescription before you run out. When leaving the hospital following hip or knee replacement, be sure that you will have ELIQUIS (apixaban) available to avoid missing any doses. **If you are taking ELIQUIS for atrial fibrillation, stopping ELIQUIS may increase your risk of having a stroke.**

What are the possible side effects of ELIQUIS?

- See **"What is the most important information I should know about ELIQUIS?"**
- ELIQUIS can cause a skin rash or severe allergic reaction. Call your doctor or get medical help right away if you have any of the following symptoms:
 - chest pain or tightness
 - swelling of your face or tongue
 - trouble breathing or wheezing
 - feeling dizzy or faint

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of ELIQUIS. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

This is a brief summary of the most important information about ELIQUIS. For more information, talk with your doctor or pharmacist, call 1-855-ELIQUIS (1-855-354-7847), or go to www.ELIQUIS.com.

Manufactured by:
Bristol-Myers Squibb Company
Princeton, New Jersey 08543 USA

Marketed by:
Bristol-Myers Squibb Company
Princeton, New Jersey 08543 USA
and
Pfizer Inc
New York, New York 10017 USA

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Based on 1289808A0 / 1289807A0 / 1298500A0 / 1295958A0
March 2014

432US14BR00770-03-01



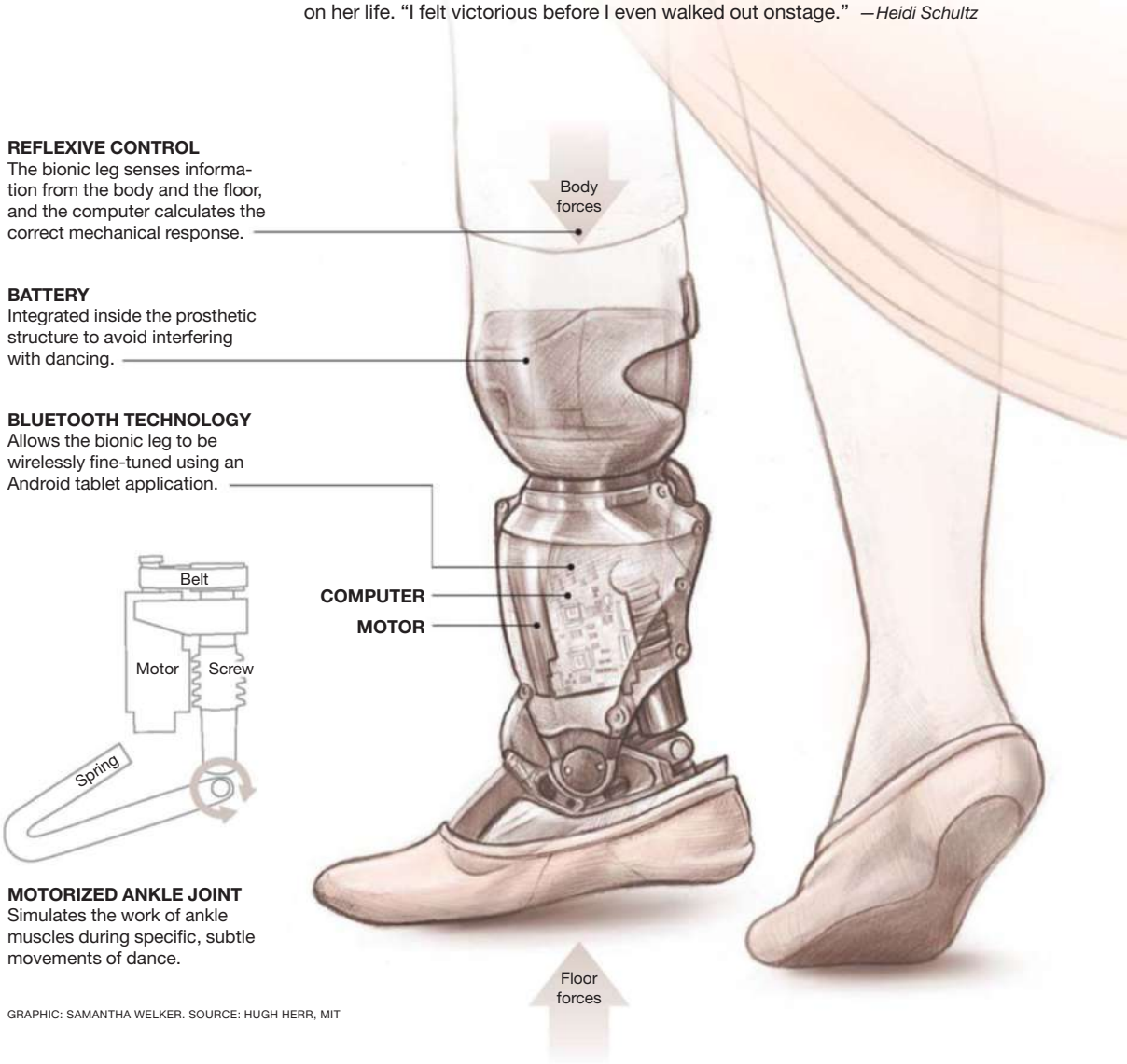
Options shown. Do not overload your vehicle. See *Owner's Manual* for weight limits and restrictions. ©2014 Toyota Motor Sales, U.S.A., Inc.

Dancing Machine

Less than a year after losing her left leg below the knee in the April 2013 Boston Marathon bombing, professional ballroom dancer Adrianne Haslet-Davis was performing the rumba again. She was aided by a prototype of a bionic leg designed specifically for dancing by Hugh Herr—a double amputee himself—and his biomechatronics team at the Massachusetts Institute of Technology Media Lab.

The biggest advantage of the robotic leg over the conventional prosthetic Haslet-Davis usually dances in is its bendable, motorized ankle. The leg has a dozen sensors that react to changing speed, torque, and position by stiffening or relaxing the ankle joint. Herr, who has also designed bionic prosthetics optimized for walking and running, hopes his research will lead to bionic limbs that are so intelligent that "the world can be continuously changing underneath one's bionic limb" and it will always respond as needed.

"I'm more fearless than I was before," says Haslet-Davis, who notes that by learning to dance with a prosthetic leg, she's also gained valuable perspective on her life. "I felt victorious before I even walked out onstage." *—Heidi Schultz*



GRAPHIC: SAMANTHA WELKER. SOURCE: HUGH HERR, MIT

JUST RELEASED:
United States Baseball Legal Tender Coin



The National Baseball Hall of Fame and the U.S. Mint have just released the FIRST EVER *curved* American coin. This legal tender half dollar has been struck to honor the 75th anniversary of the National Baseball Hall of Fame and Museum.

First Ever Curved American Coin

The coin's curved design is a first in American history. The outward curing 'tails' side of the coin depicts a baseball—complete with intricate stitching. The inward curing 'heads' side of the half dollar reveals a classic leather baseball glove, with the curve perfectly reflecting the natural shape of a weathered and well-loved baseball mitt. Among the celebrity judges who selected this FIRST EVER curved design were Hall of Famers Joe Morgan, Brooks Robinson, Ozzie Smith, Don Sutton, and Dave Winfield. The curved design is like nothing you have ever seen before. You won't believe it when you hold it!

Going…Going…GONE

Public demand for these coins has exploded and a number of versions have already sold out quickly. The 2014 Baseball Hall of Fame Half Dollar will forever go down in history as a runaway best seller.

But even though the coins are disappearing at record speed, you don't have to strike out. If you CALL NOW, you can lock in your very own piece of baseball history—not to mention the *most unusual American coin ever struck*!

Pristine Brilliant Uncirculated Half Dollar

Each 2014 Baseball Hall of Fame Commemorative Half Dollar is minted in Brilliant Uncirculated condition and comes in official U.S. Mint packaging, including the official Mint Certificate of Authenticity. Best of all, you can secure yours today for **only $29.95** (plus s/h). Due to overwhelming demand, orders are limited to a maximum of 5 coins. No dealer orders will be accepted. Lock in yours now for estimated delivery at the end of July. Hurry! A sellout is expected at any time.

When you call, ask about the extremely limited Pete Rose autographed edition.

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Structures Eat Smog

Air pollution exposure caused one in eight deaths on the planet in 2012, the World Health Organization reports. Now architects and scientists are creating air purifiers as big as buildings—because they *are* buildings. Mexico City's Manuel Gea González Hospital (pictured) last year unveiled a "smog eating" facade covered with titanium dioxide (TiO_2), a catalyst that can break down pollutants into less harmful compounds. The facade's designers say it neutralizes the pollutants from up to a thousand cars each day.

Though the jury is still out on whether TiO_2 can make a dent in global air pollution, there is strong interest. TiO_2 has been discussed for possible use in high-pollution areas of London. Next year Milan will open Palazzo Italia, a six-story pavilion with an "air cleaning cement" exterior. The approach appeals to William Suk of the U.S. National Institute of Environmental Health Sciences: "Using innovative technologies on a large, building-size scale to clean air pollution has potential." *—Mark J. Miller*

PHOTO: JÉSUS LÓPEZ

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The Ultimate Shock Absorbing Footwear

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The patented VersoShock® system was developed by Impact Research Technology and is found exclusively in Gravity Defyer® footwear. It absorbs harmful impact relieving discomfort from every step before returning energy that propels you forward. Stay more active on your feet and experience unparalleled comfort and performance.

Feel Weightless

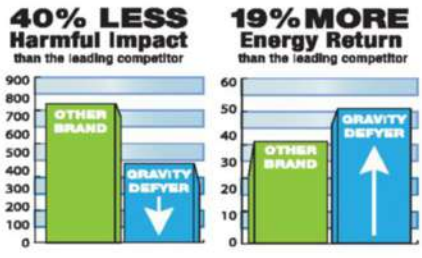
Standing, walking, and running are easier as the VersoShock® system's energy return makes you feel lighter, like you're walking on clouds.

"I decided to fulfill a life's dream and go to China…without my Gravity Defyer® [shoes] this would have been impossible." – Eleanor W



"After ordering and wearing your Gravity Defyer® [shoes], I have renewed faith that I will be able to continue my passion for senior softball. Thank you." – Ron B

"I work in a restaurant. Finally found the shoes that don't kill my legs and feet…Gravity Defyer® shoes are awesome!" – Diana B



SHOCK ABSORPTION STUDY HPW Biomechanics, 2012
Shock absorption: Measurement of maximum pressure (KPI).
Energy return: Measurement of energy returned (Joules).

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BLACK **TB9006FBL**

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BLACK **TB9007MBL**

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BLACK **TB9007FBL**

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- ✓ **Support & protect your body**
- ✓ **Stand & walk with greater ease**

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Berry Road Trip

Some 80 percent of U.S. fruits and vegetables are grown on large farms* and trucked hundreds of miles to their final destination. To track a crop's travels, two *National Geographic* reporters followed a truck filled with strawberries from a central California field to a store near the magazine's headquarters in Washington, D.C.

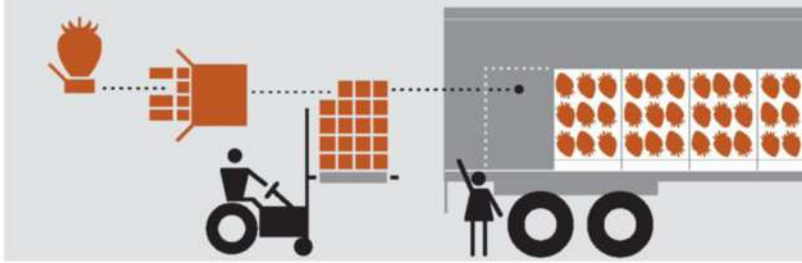
Their conclusion? Knowing exactly how a strawberry gets to market isn't so intriguing at 3 a.m. on the highway. By design, this transport is orchestrated so that consumers never have to think about a fruit's journey—until it arrives at the store, and they can inspect for bruises. —*Daniel Stone*

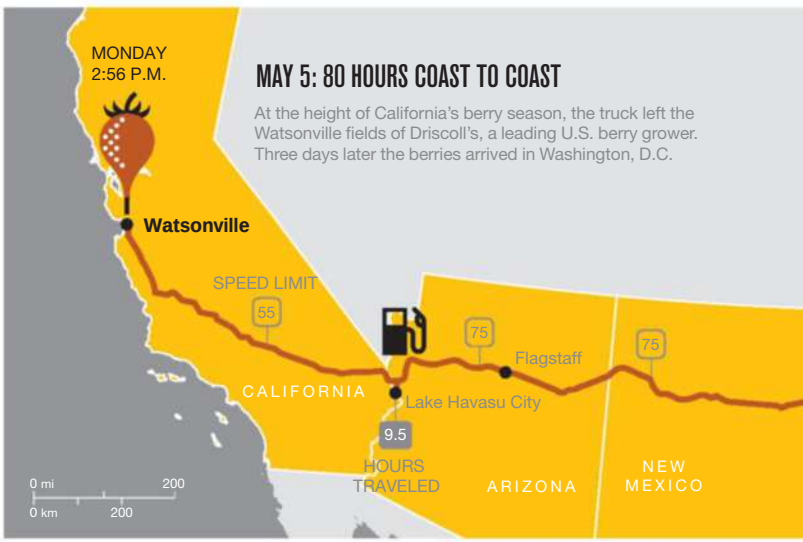
TALE OF A TRUCK

Our reporters drove behind a truck filled with strawberries. The journey from coast to coast often takes two days, sometimes three. Drivers decide the route and where to stop, bound only by their deadlines.

22,464 POUNDS OF STRAWBERRIES ON A 53-FOOT TRAILER

1 LB BERRIES PER UNIT × 8 UNITS PER CASE × 108 CASES PER PALLET × 26 PALLETS PER TRAILER = 22,464 LBS





FOOD ON THE ROAD

2.6 million

NUMBER OF REGISTERED TRUCK TRACTORS ON U.S. ROADS EACH DAY

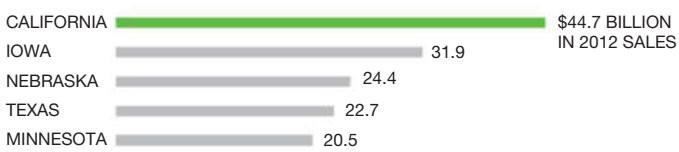
Trucks traveling east tend to carry food. Those driving west usually carry nonperishables.

5,120

TOTAL ESTIMATED MILES THE AVERAGE FOOD ITEM TRAVELS, INCLUDING ALL SUPPLY CHAIN TRANSPORT

TOP AGRICULTURAL STATES

These five states account for more than one-third of U.S. gross farm sales.



*Large farms defined as those generating at least $1 million in annual revenue

$90,000

VALUE OF CARGO, BASED ON STORE PRICE OF FOUR DOLLARS A POUND OF STRAWBERRIES

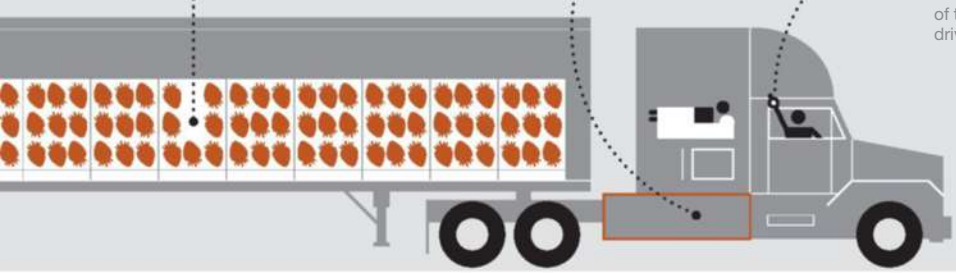
$900

COST PER FILL-UP (ABOUT 240 GALLONS); FUEL OFTEN COMES WITH A FREE SHOWER

11 hours

LIMIT OF TIME PER DAY TRUCKERS CAN LEGALLY DRIVE

On long hauls teams of two drivers alternate driving and sleeping.

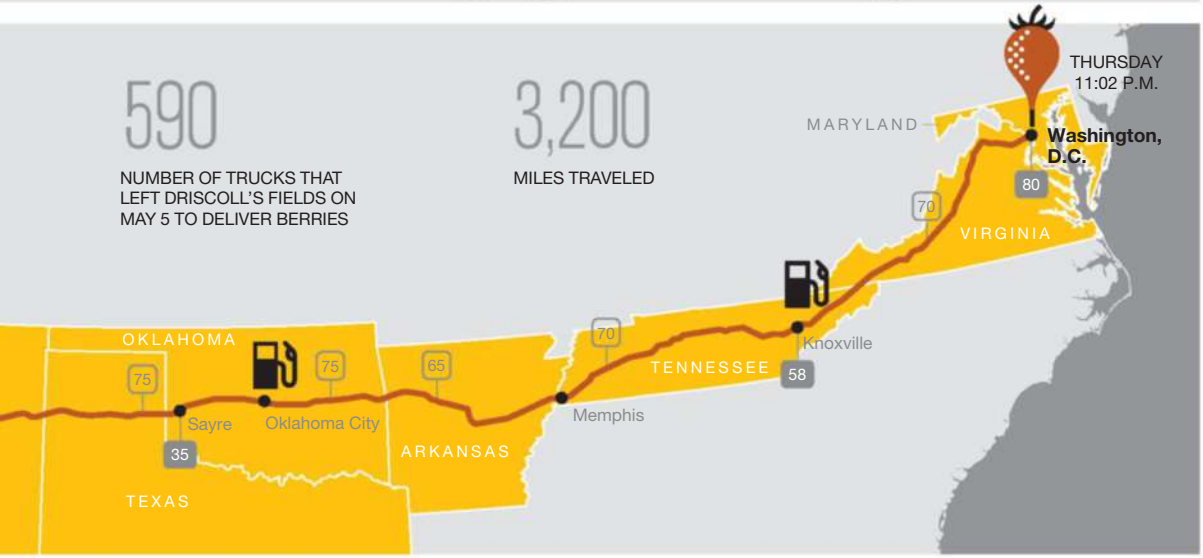


590

NUMBER OF TRUCKS THAT LEFT DRISCOLL'S FIELDS ON MAY 5 TO DELIVER BERRIES

3,200

MILES TRAVELED



U.S. TRUCKING

70%

PORTION OF U.S. AGRICULTURAL PRODUCTS SHIPPED BY TRUCK

A SMALL OPERATION

Most trucking companies are small businesses, often needing drivers to stay on the road as much as possible to remain profitable.



90.6% SIX OR FEWER TRUCKS

2.8% MORE THAN 20



U.S. SEMIS USE MORE THAN TWICE AS MUCH FUEL AS ALL U.S. AIRPLANES.

GRAPHIC: ÁLVARO VALIÑO. SOURCES: DRISCOLL'S; U.S. DEPARTMENT OF AGRICULTURE; USDA ECONOMIC RESEARCH SERVICE; U.S. DEPARTMENT OF TRANSPORTATION; AMERICAN TRUCKING ASSOCIATIONS; CARNEGIE MELLON UNIVERSITY; INMAN TRUCKING

Make Way for Millet

It ranks with buckwheat and quinoa as one of the great ancient grains. Still, for many people today millet calls to mind only one thing: bird food. True, the plant is used mainly as animal feed in the U.S. and Europe. But in parts of China, India, and Africa, millet—which is high in protein and needs little water to grow—is an important source of nourishment.

It could also be key to feeding an expanding global population. Millet can withstand drought and extreme heat, so it's an ideal crop in a changing climate, says agricultural scientist Hari Upadhyaya. What's more, the nutty-tasting grain grows quickly and resists pests.

All this tiny powerhouse needs is more exposure, says Tim Larsen, a spokesman for Colorado millet growers. "I feel its time is coming." Though introducing new foods in the U.S. can be tough, millet could benefit from a current diet trend: It's gluten free. *—Catherine Zuckerman*



PHOTO: REBECCA HALE, NGM STAFF. PENNY SHOWN FOR SCALE.

A NATIONAL GEOGRAPHIC SPECIAL ISSUE

AVAILABLE FOR DOWNLOAD ON
OCTOBER 16, 2014—WORLD FOOD DAY

Throughout the year, National Geographic has explored the question: **HOW WILL WE FEED 9.6 BILLION PEOPLE IN 2050?** The definitive compilation of the 2014 editorial series is available in an interactive edition **FREE** until November 16 on iTunes.

Go to natgeofoodapp.com

Hungry for information? Make a selection from our menu of food facts—and taste more at *natgeofood.com.*



25¢ MENU

According to the World Food Programme, just 25 cents a day is all it costs to provide a child with a nutritious school meal and extra food to take home.



HUNGRY NIGHTS

One in eight people—805 million worldwide—goes to bed hungry every night.



1,000 HEALTHY DAYS

Adequate nutrition in the first thousand days of life can protect a child from the lifelong effects of physical and mental stunting.



BUG PROTEIN

Consuming insects is a good way to boost protein intake, says the UN Food and Agriculture Organization. About two billion people around the world already eat bugs regularly.



MIGHTY PEANUT

A calorie-rich, vitamin-fortified form of peanut paste has saved millions of starving children—and provided a new market for African peanut farmers.



HUNGRY STUDENTS

Some 66 million children go to school hungry across the developing world. More than a third of them are in Africa.



HELP WOMEN, CUT HUNGER

The number of hungry worldwide could be reduced by as much as 150 million if women farmers were given the same access to resources as men.

PHOTO: REBECCA HALE, NGM STAFF. ART: ÁLVARO VALIÑO

Advertisement



WATCH HUNGER STOP

In 2013 Michael Kors launched Watch Hunger Stop, a campaign to help end world hunger. Joining forces with the United Nations World Food Programme (WFP), the brand committed its global reach and resources to WFP's goal of building "a world with zero hunger." Academy Award-winning actress Halle Berry has added her unique talent and limitless compassion to the cause. To date, Watch Hunger Stop has helped WFP deliver more than five million meals to children in need through its school meals program. In July, Berry accompanied WFP on a field visit to rural Nicaragua, together with teams from Michael Kors and National Geographic. The resulting photographs and video tell a compelling story of progress and possibility. National Geographic photographer Tyrone Turner explains, "As a photojournalist, I'm often called upon to bear witness to the world's problems. That's why it was a dream for me and the other folks on our team to be able to document a partnership focused on solutions. It was an incredible experience to see the impact that a daily serving of quality food has on the lives of children."







WATCH THE VIDEO, SEE MORE PHOTOS AND LEARN HOW YOU COULD WIN A CHANCE TO ACCOMPANY WFP ON A FIELD VISIT. ALL AT WATCHHUNGERSTOP.COM

MICHAEL KORS

#WATCHHUNGERSTOP

WFP World Food Programme wfp.org



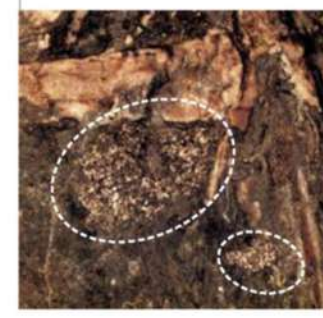
Just three inches long, this winged fossil has grains of pollen in the stomach area. The bird belonged to a now extinct species called *Pumiliornis tessellatus*.

Earliest Bird Pollinator

Some 47 million years ago a tiny bird stuck its beak into a flower to sip nectar, swallowed clumps of pollen, and died shortly thereafter. Its fossilized remains preserve that last meal in its stomach—the earliest evidence of a bird that must have carried pollen from plant to plant.

"It's the only fossil bird we know for sure was a pollinator," says Gerald Mayr, an ornithologist at the Senckenberg Research Institute in Frankfurt, Germany, who studied the specimen after its discovery in 2012 in the Messel oil shale pit. "Stomach contents are not that common in the fossil record, and they mainly consist of seeds and fish remains."

There's only indirect proof for the second earliest known bird pollinators: fossils of hummingbirds from 30 million years ago. *—A. R. Williams*



PHOTOS: SVEN TRÄNKNER; GERALD MAYR (DETAIL)



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Alexander Graham Bell with his grandson Melville. Beinn Bhreagh, Nova Scotia. Copyright © 2014 National Geographic Society

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Retiring Delayed

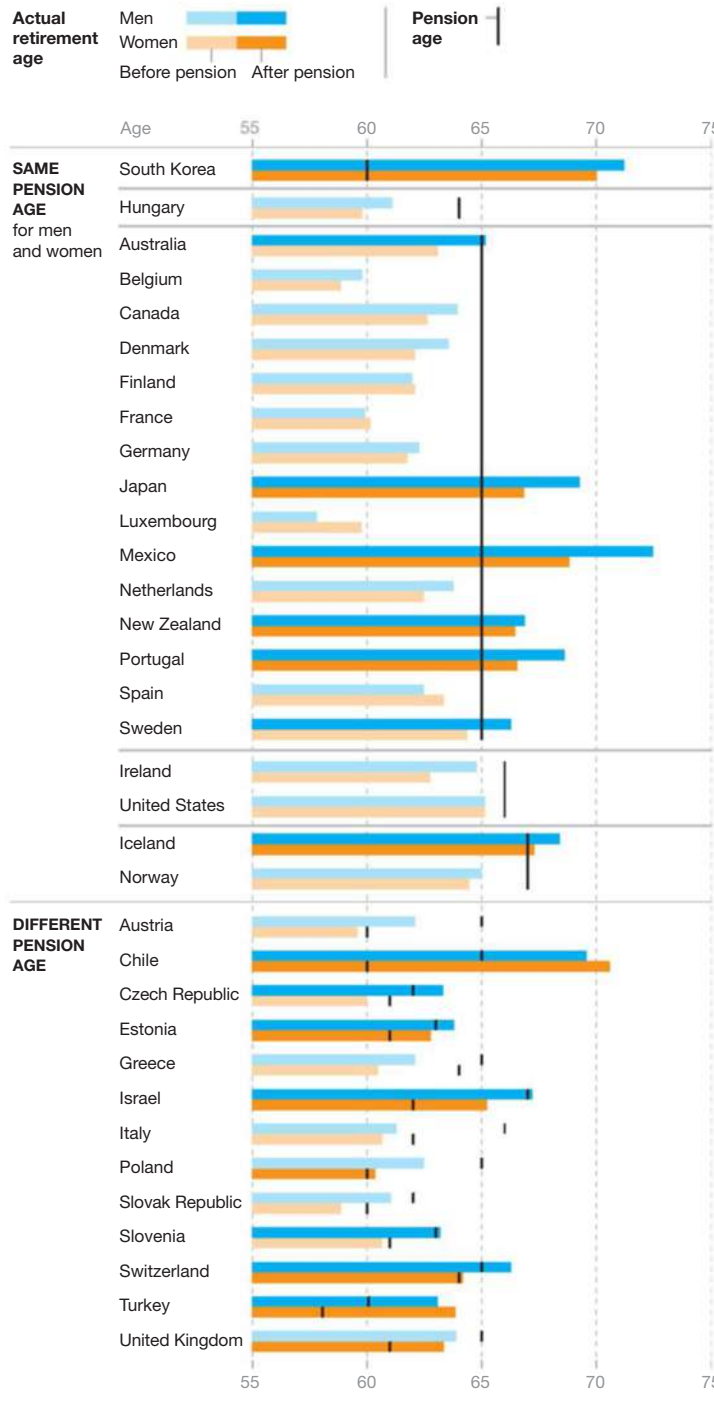
Every worker, at some point, may imagine retiring. But for the next generation of the world's workers, that dream is growing more distant.

As nations reform pension systems in hopes of reducing future costs, more people will get smaller public pensions and stay on the job longer, says a 2013 report by the Organisation for Economic Co-operation and Development. By 2050 most of the 34 OECD-member countries will raise the retirement age to at least 67 years, says the *Pensions at a Glance* report.

National pension systems face growing pressure as people live longer. Raising retirement ages and promoting private pensions will help address that problem, "but more needs to be done," says Monika Queisser, the OECD's head of social policy and one of the authors of the report. "More efforts need to be made to keep older workers in the workforce, provide training, and promote healthy working conditions."

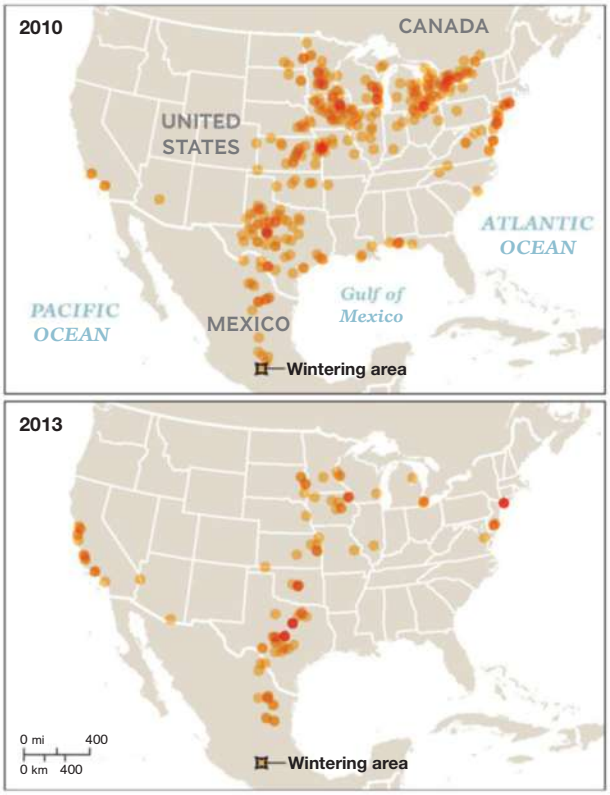
The poverty rate among older people has been declining in 20 OECD countries, the report says; still, women over 65 are about one and a half times as likely to live in poverty as men over 65. In many nations older workers are safeguarding their solvency by delaying retirement, working into their late 60s and beyond. —*Judi Hasson*

QUITTING TIME
Eligibility compared with actual retirement ages around the world



GRAPHIC: LAWSON PARKER AND EMILY M. ENG, NGM STAFF. SOURCE: OECD


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Monarchs migrate up to 3,000 miles each fall to their wintering area in central Mexico. In the past few years citizen scientists have recorded a sharp drop in the number making the trip.

Recorded overnight monarch roost sites
Darker orange dots indicate multiple sites in the same locale.

A Vanishing Migration

Fewer monarch butterflies are crossing North America to winter in Mexico, says the World Wildlife Fund Mexico. In 2004 an estimated 550 million completed the winter migration; last season an estimated 33 million made it, according to the fund's count. Although illegal deforestation and severe weather contributed to the decline, recent research suggests that the biggest culprit is farms' large-scale use of herbicides that destroy milkweed. Monarch caterpillars need to feed on the plant—but it decreased 21 percent in the United States between 1995 and 2013. That doesn't bode well for the butterflies, whose life span is so short that those making the next migration will be the great-grandchildren of the previous migrators. For this winged orange icon, survival is a group effort. *—Lindsay N. Smith*



SNAKING THEIR WAY HOME

Move over, homing pigeons. When scientists in the Everglades radio-tagged and relocated invasive Burmese pythons, the snakes navigated up to 20 miles to return to their home turf. Biologist Shannon Pittman says the reptiles may steer using celestial cues. It's bad news for South Florida if the snakes invade new areas, knowing they can always get home. *—Christine Dell'Amore*

NGM MAPS. SOURCE: JOURNEY NORTH. PHOTOS: JOEL SARTORE; DON FARRALL, GETTY IMAGES (TOP)

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VISIONS





United States
Lightning strikes in Grand Canyon National Park about 26,000 times each year. Most bolts hit the rim of the canyon in northern Arizona. But some—like this one, captured in a 25-second exposure—can hurtle from cloud to ground inside the canyon itself.

PHOTO: SCOTT STULBERG



England
Dozens of muddy men clamber across ropes during the annual Tough Guy competition in Perton. The course—roughly eight miles of obstacles including fire, ice, mud, and barbed wire—draws thousands of hardy contestants each winter.

PHOTO: ESPEN RASMUSSEN, PANOS PICTURES





Australia
Felled by a power line and dead of a broken neck, an Australian pelican becomes an unlikely still life in Brisbane. To turn tragedy into tableau, the photographer made this image using a flashlight and a long exposure—then buried the bird in her garden.

PHOTO: MARIAN DREW

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Editor's Choice

Daily Dozen Editors pick 12 photos submitted online each day. Here are our favorites this month.



EDITOR'S NOTE

"We see hundreds of fireworks photos every day. They're easy because they're eye-catching. Dor's stood out. The glow is soft, and the soldiers add context to the celebration." —*Jeanne Modderman,* National Geographic *photo editor*



Dor Kedmi *Jerusalem, Israel*
At one of Israel's Independence Day celebrations in Jerusalem, Kedmi looked for a way to capture the traditional fireworks show. "I loved how the streetlight shimmered through the soldiers, so I waited there for the show to start," he says.

Cletus Nwadike *Aneby, Sweden*
Nwadike was visiting his family in Nigeria when he saw his two young cousins playing a game. The two held each other's water cup until one could drink no more and gave up. Nwadike found it playful and symbolic of their mutual dependence.



Amazing New Hybrid Runs Without Gas

The new face of time? Stauer's Compendium Hybrid fuses form and functionality for UNDER $30! Read on...

Innovation is the path to the future. Stauer takes that seriously. That's why we developed the ***Compendium Hybrid***, a stunningly-designed hybrid chronograph with over one dozen analog and digital functions that is more versatile than any watch that we have ever engineered.

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Self-Portrait

Assignment We asked members to turn the camera around and show us who they are.





EDITOR'S NOTE

"Making photographs about your vulnerabilities and struggles is an important exercise. The idea wasn't to share a lucky shot, but an image thoughtfully considered and planned."

—*Rebecca Hale,* National Geographic *photographer*

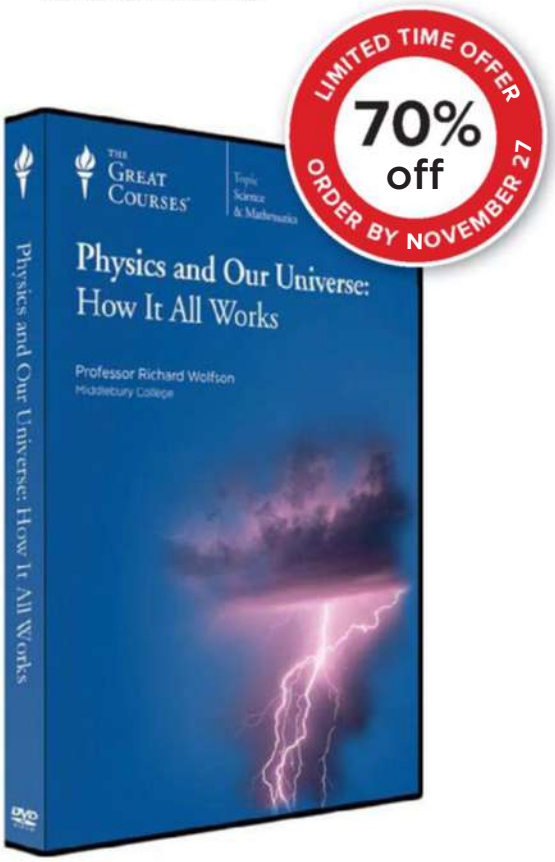


Charles Hedeen *Three Forks, Montana*
For his job as a crane operator, Hedeen has lots of boots. While packing his gear, he noticed the symmetry, then set up his tripod. The last step: He took off his pants. "I've got pasty white legs, which I thought might add contrast."

Liesa Slebos *Cottbus, Germany*
Slebos wanted to find a way to show the societal pressure women feel to be thin and beautiful. "This picture tells the story of hundreds of thousands of girls who are not satisfied with their body, even if it is perfectly healthy," she says.

Helene Barbe *Jan Juc, Australia*
Barbe's university assignment was to create book covers for Jane Austen novels. For *Northanger Abbey* she placed her camera under a sheet of glass and pointed it up. "Beauty is only skin deep," she says, so she tried to blur her face.

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Faces

A hiking party poses at the rim of a crevasse on Mount Rainier in Washington State in this photo—which arrived at the *Geographic* in 1919. A look through the loupe shows one couple especially well prepared for a day on sunny slopes: Their faces are slathered with sunblock.

"The guides will provide the calked shoes, clothing, alpenstocks, colored glasses, and face paints necessary for trips over snow and ice fields," explains a National Park Service guidebook to Rainier from that year. "The climb is such a long one and the altitude gained so high that none but those who have previously prepared themselves by preliminary shorter climbs can hope to accomplish the feat with anything like genuine enjoyment." *—Margaret G. Zackowitz*

PHOTO: NATIONAL PARK SERVICE/NATIONAL GEOGRAPHIC CREATIVE

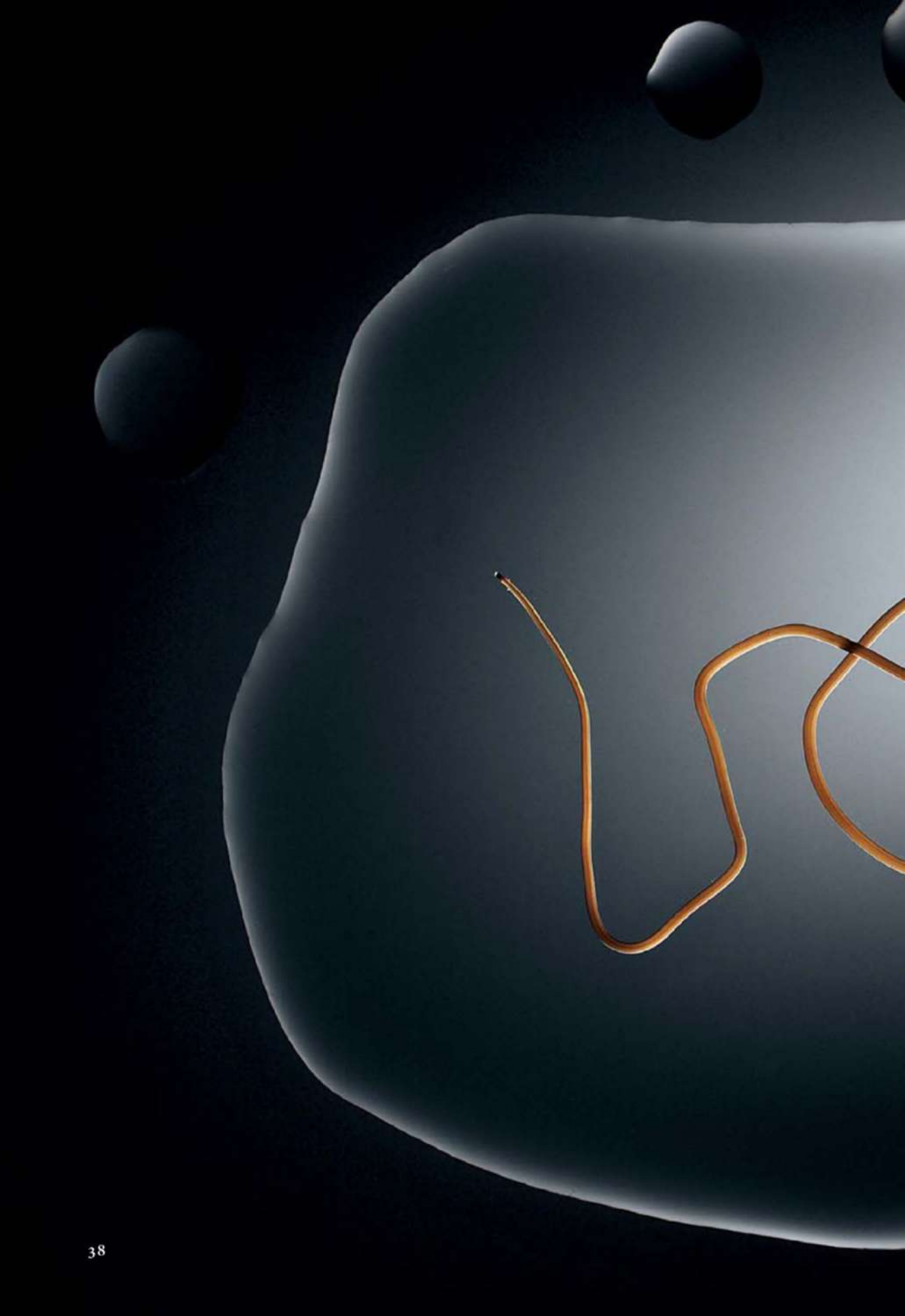


Parasitic barnacle *Heterosaccus californicus*
Sheep crab *Loxorhynchus grandis*

Welcome to a freakish world where parasites compel their hosts to do their bidding. A male sheep crab infected by a parasitic barnacle is literally feminized. It stops developing fighting claws, and its abdomen widens, providing a "womb" for the barnacle to fill with its brood pouch. Nurtured by the crab, the eggs hatch. Thousands of baby barnacles disperse to infect anew.

ECOLOGICAL PARASITOLOGY GROUP, UNIVERSITY OF CALIFORNIA, SANTA BARBARA


CKERS





Horsehair worm
Paragordius varius

House cricket
Acheta domesticus

The house cricket loses its will—and its life—to the horsehair worm. Larvae of the parasite infiltrate the cricket when it scavenges dead insects, then grow inside it. The cricket is terrestrial, but the adult stage of the worm's life cycle is aquatic. So when the mature worm is ready to emerge, it alters the brain of its host, driving the cricket to abandon the safety of land and take a suicidal leap into the nearest body of water. As the cricket drowns, an adult worm emerges, sometimes a foot in length.

BEN HANELT, UNIVERSITY OF NEW MEXICO



From the wasp's point of view, this is a very positive development. A growing *D. coccinellae* wasp nestled in its cocoon is intensely vulnerable. Lacewing larvae and other insects will happily devour it. But if one of these predators approaches, the ladybug will thrash its limbs, scaring off the attacker. In effect it has become the parasite's bodyguard. And it will continue to loyally play this role for a week, until an adult wasp cuts a hole through the cocoon with its mandibles, crawls out, and flies away.

Only then do most of the ladybug zombies die, their service to their parasite overlord complete.

This sinister scene was not conceived by a scriptwriter. Across much of North America, wasps are converting ladybugs into zombie bodyguards in backyards and empty lots, in farm fields and wildflower meadows. Nor is the spotted lady beetle unique. Scientists are finding the same is true for a vast number of host species, ranging from insects to fish to mammals. They serve their parasite even if they must literally hurl themselves to their own death to do so. Across the natural world the same question arises again and again: Why would an organism do all it can to ensure its tormentor's survival rather than fight for its own?

Serving as bodyguard is only one of the protective services provided to parasites by their hosts. A fly that infects bumblebees causes them to burrow into the ground in autumn, right before the fly emerges to form a pupa. In the ground the fly is protected not only from predators but also from the cold of winter.

In Costa Rica, the orb-weaving spider *Leucauge argyra* will go to extravagant lengths to accommodate the needs of *Hymenoepimecis argyraphaga,* another freeloading wasp. The female glues its egg to the host's body. After the larva emerges, it pokes a few holes in the spider's abdomen and sucks its blood. When the larva has grown to full size, in a couple of weeks, the spider takes it upon itself to rip down its own web and build a new one of a radically different shape. Instead of a multistranded net designed for catching flying insects, the new web is merely a few thick cables converging at a central point. Having sucked its host dry, the larva spins its cocoon on a thread hanging from the intersection of the cables. Suspended in the air, the cocoon is nearly impossible for would-be predators to reach.

Parasites can also coax a host to guard them while they're still living inside it. Before infecting a human host, *Plasmodium,* the protozoan that causes malaria, spends the first stages of its life cycle in a mosquito. The mosquito needs to drink blood to survive. But this behavior poses a risk

Carl Zimmer last wrote on new ways of exploring the brain in the February 2014 issue. Biologist and photographer Anand Varma communicates science through images. Matt Twombly is a graphics editor at the magazine.

to the protozoan, because the mosquito may be crushed by the hand of an annoyed human victim, eliminating the opportunity for *Plasmodium* to move to the next stage of its life cycle, in the human. To reduce this risk while it is still developing in the mosquito, *Plasmodium* makes its host blood shy, seeking fewer victims each night and giving up faster if it can't find a gusher of blood.

Once *Plasmodium* has matured and is ready to enter a human host, it manipulates the mosquito's behavior in the opposite direction. Now the mosquito grows thirsty and foolhardy, seeking out more humans each night and biting repeatedly even if it is already full. If the mosquito dies at the hand of a human, it is no longer of any consequence. *Plasmodium* has moved on.

While *Plasmodium* tinkers with the ordinary behavior of its host to get to the next stage of its life cycle, other parasites wreak far more radical changes—often with fatal results. Killifish, for example, normally stay away from the surface of the water to avoid being picked off by wading birds. But when they're infected with flatworms known as flukes, they spend more time near the surface and sometimes roll so that their silvery bellies glint in the light. Infected killifish are far more likely to be picked off than healthy ones. And it just so happens that the gut of a bird is where the flukes need to go next to mature and reproduce.

The best known mindsucking parasite plays out a similar manipulation on land. Along with other mammal species, rats and mice can be infected with *Toxoplasma gondii,* a single-celled relative of malaria-causing *Plasmodium.* The parasite can form thousands of cysts in the brain of its host. To take the next step in its life cycle, *Toxoplasma* has to get inside the gut of a cat. *Toxoplasma* doesn't have the means to transport itself from a rat's brain to a cat's gut. But if its rat host gets eaten by a cat, the parasite can reproduce. Scientists have discovered that rats infected with *Toxoplasma* lose their normal fear of the smell of cats. In fact some infected rats become downright curious about the odor of cat urine, making themselves easy targets for a swipe of a cat's paw—and thus raising the odds that *Toxoplasma* will advance through its life cycle.

How mutations and natural selection could give rise to such creepy powers is a particularly intriguing puzzle for evolutionary biologists. One useful concept for thinking about it comes from biologist Richard Dawkins, author of the landmark book *The Selfish Gene.*

In that book Dawkins argued that genes evolve to make copies of themselves more successfully. Our bodies may be important to us, but from our genes' point of view, they are nothing more than vehicles to get themselves intact into the next generation. The entire collection of the genes that make up you or me is called our genotype. The sum total of all





SOURCES: ROBERT M. SAPOLSKY AND PATRICK HOUSE, STANFORD UNIVERSITY


INSTEAD IT SHOWS NO FEAR OF THE STALKING FELINE, MAKING IT EASY PREY.
A CAT'S INTESTINAL TRACT IS THE ONLY PLACE TOXO IS KNOWN TO REPRODUCE. FROM THERE, IT SPREADS THROUGH CAT EXCREMENT.
WHICH IS EXACTLY WHY TOXO WANTS TO BE PART OF YOUR CAT'S NEXT MEAL.
TOXO CAN INFECT THE BRAIN OF NEARLY ANY WARM-BLOODED ANIMAL, EVEN HUMANS.
THOUGH RARELY FATAL, THE PARASITE CAN HARM A PREGNANT WOMAN'S FETUS. BUT FOR SOME REASON IT NEVER REACHES A CAT'S BRAIN.
SO DON'T WORRY. YOUR CAT IS SAFE.

the bodily parts and functions that our genotype creates to advance its cause—you or me—is called our phenotype.

It occurred to Dawkins that we don't have to limit phenotypes to the boundaries of our bodies. They also include the behaviors brought about by our genes. A beaver's genes encode its bones and muscles and fur. But they also encode the brain circuits that lead the beaver to gnaw at trees to build dams. The beaver benefits from the pond created by the dam in many ways. It's harder for predators to attack the beaver's lodge, for example, because of deeper surrounding water. If a gene mutation gives rise to a beaver that builds even better dams, that particular beaver phenotype may stand a better chance of survival and, on average, have more baby beavers itself. As a result, the mutation will become more common over the course of many generations. From an evolutionary perspective, the dam—and even the pond that it creates—is as much an extension of the beaver's genes as its own body is.

If the power of a gene can extend to manipulation of the physical world, Dawkins wondered, could it not extend as well to the manipulation of another living creature? Dawkins argued that it could, and he pointed to parasites as his prime example. The ability of a parasite to control the behavior of a host is encoded in its genes. If one of those genes mutated, the host's behavior would change.

Depending on how it changed, the mutation might help or harm the parasite. If a flu virus mutates so that its victims lock themselves away and starve to death, the virus will be unlikely to spread to other hosts, and it will disappear from the population of viruses. A mutation in a parasite that influences a host's behavior for the better will become more common. If a wasp acquires a mutation that compels its ladybug host to begin to act as a bodyguard, for example, its offspring carrying that trait will thrive, because fewer of them will be killed by predators.

Dawkins first developed these ideas in his 1982 book *The Extended Phenotype*. In many respects it was a book far ahead of its time. In the 1980s scientists had carefully studied only a few examples of parasites manipulating their hosts' behavior. But if the hypothesis was correct, there had to be genes within the parasites that trumped the genes in the hosts themselves that normally controlled their actions.

Thirty-two years later, scientists are finally opening the black box of

A tiny amphipod, *Hyalella azteca,* lives in obscurity at the murky bottom of lakes and ponds—unless it's invaded by the larva of a thorny-headed worm. When the larva matures, the amphipod abandons its safe dark home and swims toward the light of the surface. For the host, it's a fatal mistake. Waiting above are ducks and other waterfowl keen to eat the amphipods as they surface. But for the parasite—turned orange by pigments pilfered from its victim's tissue—it's just part of the plan. Thorny-headed worms can grow to maturity only in the guts of waterfowl.

Thorny-headed worm
Pseudocorynosoma constrictum

Amphipod
Hyalella azteca

LINDEN E. REID, UNIVERSITY OF NEBRASKA CEDAR POINT BIOLOGICAL STATION



parasite mind control. Frederic Libersat of Ben-Gurion University and his colleagues, for example, are dissecting the sinister attacks of the jewel wasp, *Ampulex compressa.* The wasp stings a cockroach, transforming it into a passive zombie. The wasp can then walk its drugged victim into a burrow by the roach's antenna, like a dog on a leash. The roach is perfectly capable of movement. It just lacks any motivation to move on its own behalf. The wasp lays an egg on the roach's underside, and the roach simply stands there as the wasp larva emerges from the egg and digs into its abdomen.

What is the secret hold that the wasp has over its victim? Libersat and his colleagues have found that the wasp delicately snakes its stinger into the roach's brain, sensing its way to the regions that initiate movements. The wasp douses the neurons with a cocktail of neurotransmitters, which work like psychoactive drugs. Libersat's experiments suggest that they tamp down the activity of neurons that normally respond to danger by prompting the cockroach to escape.

The scientists have documented the jewel wasp's neurosurgery in astonishing detail—but they're a long way from the full story. The wasp's venom is a veritable punch bowl of different chemicals, and Libersat and his colleagues have yet to determine which ones affect the behavior of the cockroach and how they do. But so far their research is entirely consistent with Dawkins's theory of the extended phenotype: The genes that encode the venom molecules enlist the cockroach in the wasp's survival plan by providing an ideal nursery for the wasp's young.

In a handful of cases scientists have begun to pinpoint which of the parasite's genes control their host's behavior. Baculoviruses, for example, infect the caterpillars of gypsy moths and a number of other species of moths and butterflies. The parasite invades its host's cells, hijacking them to make new baculoviruses. On the outside the caterpillar appears normal, continuing to munch on leaves as before. But the food it eats is not becoming more caterpillar tissue. Instead it's becoming more baculoviruses.

When the virus is ready to leave its host, the caterpillars undergo a radical change. They become agitated, feeding without rest. And then they begin to climb. Instead of stopping in safe spots out of the way of predators, the infected caterpillars creep higher into the trees, remaining

Parasitic flatworm
Ribeiroia ondatrae

American bullfrog
Lithobates catesbeianus

PIETER JOHNSON LAB, UNIVERSITY OF COLORADO BOULDER

After the flatworm *Ribeiroia ondatrae* reproduces asexually inside a snail, its larvae find a bullfrog tadpole and burrow their way through its skin, forming cysts around the frog's developing limbs. With legs added, subtracted, or compromised, the ungainly victim is easy prey for frog-eating birds like herons. Inside the heron, the parasite reproduces sexually. Its eggs reenter the water when the bird defecates, infecting new snails to start another round.



SOURCE: PIETER JOHNSON LAB, UNIVERSITY OF COLORADO BOULDER


AS THE TADPOLE GROWS INTO A FROG, THESE CYSTS CAUSE GROTESQUE DEFORMITIES.


THE CRIPPLED FROGS ARE PITIFULLY INCAPABLE OF AVOIDING DANGER...


...EVEN WHEN THEY SEE IT COMING.


AND THEY FALL PREY TO THE SWIFT BEAKS OF WATERBIRDS LIKE THIS HERON.


THE HERON, WITH A FROG FULL OF PARASITES IN ITS BELLY, FLIES OFF TO ANOTHER POND, SPREADING THE PARASITE IN ITS FECES TO BEGIN THE CYCLE ANEW.





Ophiocordyceps fungus
Ophiocordyceps spp.

Amazonian ant
Dinoponera longipes

Pity the ant afflicted by the mindsucker *Ophiocordyceps.* When spores of the fungus land on an ant, they penetrate its exoskeleton and enter its brain, compelling the host to leave its normal habitat on the forest floor and scale a nearby tree. Filled to bursting with fungus, the dying ant fastens itself to a leaf or another surface. Fungal stalks burst from the ant's husk and rain spores onto ants below to begin the process again.

DAVID HUGHES LAB, PENN STATE UNIVERSITY

on top of leaves or on tree bark in daylight hours, when they are easily seen by predators.

The baculoviruses carry genes for several enzymes. When they're ready to leave their host, certain genes become active in caterpillar cells, producing a torrent of enzymes that dissolve the animal into goo. As the caterpillars dissolve, clumps of viruses shower down onto the leaves below, to be ingested by new caterpillar hosts.

To Kelli Hoover and David Hughes of Penn State University and their colleagues, the climbing behavior of the caterpillars seemed like an exquisite example of an extended phenotype. By causing their hosts to move up in trees, the baculoviruses increased their chances of infecting a new host down below. To test Dawkins's idea, they examined the genes in baculoviruses, to see if they could find one that controlled the climbing of caterpillars.

When the researchers shut down a single gene in the virus, called *egt*, it continued to infect caterpillar cells and replicate as before, even turning the caterpillars to goo as before. But baculoviruses without a working copy of *egt* could not cause the caterpillars to climb trees. It's unlikely that many other parasites control their hosts with a single gene; an animal's behavior is typically influenced by a number of its own genes, each contributing a small part to the sum. So it's probable that many parasites control their hosts with a multitude of their own genes.

And what of *D. coccinellae* and its hapless ladybug host? While at the University of Montreal, Fanny Maure and her colleagues made a startling discovery: In turning its victim into a willing bodyguard, the wasp itself may only be acting as the extended phenotype of yet another organism. The researchers found that when a wasp injects an egg into a ladybug victim, she also injects a cocktail of chemicals and other substances—including a virus that replicates in the wasp's ovaries. Some evidence suggests it is this virus that immobilizes the ladybug, protecting the wasp's cocoon from intruders.

The virus and the wasp have the same evolutionary interests; turning a ladybug into a bodyguard produces more wasps, and more wasps beget more viruses. And so their genes work together to make the ladybug their puppet. The *D. coccinellae* wasp may not be the puppet master it once seemed. Instead it hides another puppet master within. ▯

MORE ONLINE

ngm.com/more



A third graphic novella tells the macabre tale of the iridescent-blue jewel wasp and her victim, the American cockroach. The location: New Caledonia, South Pacific. The lesson: Mother Nature's creativity has no limit.

VIDEO

"Magically the images on my screen started to dance to the music, and suddenly I had an idea."

—ANAND VARMA

Like the spotted ladybug, the caterpillar of the cabbage butterfly plays bodyguard to a parasitic puppet master. A female white butterfly wasp injects a caterpillar with several dozen eggs. The larvae hatch, feed, grow…then paralyze their still living host and chew their way out. As the caterpillar comes to, the larvae spin little cocoons beneath it. Rather than leave them to fend for themselves, their enslaved host spins an extra silk layer around the cocoons, then stands guard over the brood, flinging its head back and forth to ward off predators.

White butterfly wasp
Cotesia glomerata

Cabbage butterfly
Pieris brassicae

JEFF HARVEY LAB, NETHERLANDS INSTITUTE OF ECOLOGY





SORROW ON THE MOUNTAIN

How the shocking avalanche that killed 16 expedition workers unfolded on Mount Everest—changing life on the mountain forever



Birds ride the wind as Lakpa Sherpa, a guide and expedition company owner, pauses for tea and a moment of reflection in 2013 among the peaks near Everest.





April 18, 2014 Rescuers in the Khumbu Icefall dig for survivors and bodies among mansion-size blocks of ice about three hours after the avalanche. Eleven of the 16 victims died at a single spot at upper left, where climbers are searching.

ANDY TYSON

THE 16 WHO PERISHED: MINGMA NURU, DORJE SHERPA, ANG TSHIRI, NIMA SHERPA, PHURBA ONGYAL, LHAKPA TENJING SHERPA, CHHIRING ONGCHU SHERPA, DORJE KHATRI, DORJE SHERPA, PHUR TEMBA SHERPA, PASANG KARMA SHERPA, ASMAN TAMANG, TENZING CHOTTAR, ANKAJI SHERPA, PEM TENJI SHERPA, ASH BAHADUR GURUNG

By Chip Brown
Photographs by Aaron Huey

On what would be the darkest day

world's highest mountain,

Nima Chhiring, a 29-year-old Sherpa from the village of Khumjung with sunburned cheeks and a thatch of black hair, marched to work at 3 a.m. He had a 65-pound canister of cooking gas on his back. Behind him was the temporary village of Everest Base Camp, where the members of some 40 international expeditions were asleep in their tents or tossing restlessly in the thin air of 17,290 feet. Above him a string of headlamps flickered in the darkness, as more than 200 Sherpas and other Nepali workers filed through the Khumbu Icefall. Considered among the most hazardous sections of any regularly

climbed mountain anywhere, the icefall is a steep, constantly shifting labyrinth of teetering seracs, crevasses, and contorted ice that spills 2,000 feet down a gorge between Mount Everest's west shoulder and Nuptse, the 25,791-foot peak that looms over Base Camp.

Many of Nima Chhiring's fellow Sherpas had trudged into the icefall even earlier on that morning, April 18. They'd had their typical breakfast of tea and a barley-flour porridge named tsamba, and shouldered loads packed the night before. Some were hauling ropes, snow shovels, ice anchors, and other gear they would use to set a handrail of fixed lines all the way to Everest's summit at 29,035 feet. Others were lugging the equipment with which they would establish four intermediate camps higher on the mountain—sleeping bags, dining tents, tables, chairs, cooking pots, and even heaters, rugs, and plastic flowers to pretty up mealtime for their clients.

On some Sherpas were traces of the roasted barley flour they had rubbed on each other's faces during the puja ceremonies the previous day, when they petitioned Jomo Miyo Lang Sangma, the goddess who dwells on Everest, for safe passage and "long life." A number of the climbers already had made several round-trips since the route had been opened in early April by the Sherpa specialists known as the Icefall Doctors. The line of fixed ropes and aluminum ladders spanning cliffs and seams in the ice was not markedly different from the route of recent climbing seasons, though it was closer to the avalanche-raked flank of the west shoulder, where a hanging glacier bulged ominously a thousand feet above.

Even with loads of up to a hundred pounds, most of the Sherpas were fit enough to make the 2.1-mile climb to Camp I in three and a half hours or less. An hour above Base Camp, Nima Chhiring, who was working for a Chinese expedition, reached the area known as the Popcorn, where the route steepened through a hash of broken ice, and ladders were numerous. Further on, at a flat area known as the Football Field, climbers often paused for a rest, and it was common to hear ice groaning as the Khumbu Glacier shuddered forward at the rate of a few feet a day. Above the Football Field was another especially dangerous zone of mansion-size ice blocks and precarious towers, past which Nima Chhiring's trip would get easier as the Khumbu Glacier leveled out in the massive white plain known as the Western Cwm.

About 6 a.m., above the Football Field, Nima Chhiring reached the base of an ice cliff about 40 feet high. There he began the awkward task of climbing three lashed-together aluminum ladders with the heavy pack on his back, metal crampons on his boots, and an ascender in his hand that he had to clip and unclip as he moved past the anchors of the fixed rope. When he reached the top, he was dismayed to see scores of mountain workers backed up on a sloping ledge of ice about the size of a teahouse dining room. Some were standing around smoking. Some were queued up and waiting to climb down a trench on two lashed-together ladders. At least once that morning, shifting ice had caused the anchors on the low end of the down-climb ladders to come loose and had backed up traffic on the route. Those who had arrived at this section at 5 a.m. had noted long delays, even though the ladder had been reanchored. When Nima Chhiring got there an hour later, he found the anchors had come loose again.

"I think there were more than a hundred people stopped there; many were down-climbing, holding on to the rope. It would take half an hour to get past the backup. At that moment I became very scared," he said.

"My ear is crying"

In Nepal premonitions of danger are sometimes experienced as a buzzing, high-pitched sound, a phenomenon called *kan runu,* or crying ear. Nima Chhiring, who had been to the summit of Everest three times, had heard his ear cry before and knew better than to ignore it. He was racked with indecision: Continue dutifully on to Camp I with his load, or deposit the gas canister as far as he'd carried it and go down immediately? He tried to radio his sirdar at Base Camp, but the boss had gone to Namche Bazar for supplies, and Nima Chhiring could raise only the camp cook. Nima Chhiring told the cook that his ear was crying and that he was going to leave his load clipped to the fixed ropes and descend. Other Sherpas asked him what he was doing.

"I said, 'My ear is crying, and we will hear something bad has happened. I am going down; you should go down too,'" he recalled. He estimated the time was about 6:15.

Word of Nima Chhiring's crying ear spread. Five Sherpas above the triple ladder dumped their loads and started down. Two working for the Canadian outfitter Peak Freaks had been delayed below the triple ladder and retreated because their feet were freezing. Others didn't feel they could alter their itinerary on the edict of a crying ear or a cold foot. Between the jam-up and the Football Field, Nima Chhiring passed Sherpas he didn't know and Sherpas he did. Among the latter: Phurba Ongyal, 25, from Pangboche, who had told his sister this season on Everest would be his last; Lhakpa Tenjing Sherpa, 24, who had a wife and two-month-old daughter in Khumjung; and Ang Tshiri, at 56, one of the oldest Sherpas on the mountain, who was heading up the icefall for what he said was the last time. After 13 years as a cook at Camp II, he planned to retire to his restaurant in Thamo, also called Camp II. Nima Chhiring also passed Ang Tshiri's half brother Dorje Sherpa, 39, who lived in a dirt-poor house with his family way up the Bhote Kosi river valley in Tarngga, a two- or three-day walk from Everest.

"I told many of them my ear was crying, and they should turn around," Nima Chhiring said. "They said, 'We have pressure to get up there. We have to go on.'"

"Nima Chhiring told me not to go up," said Mingma Gyaljen Sherpa, a 33-year-old from Namche Bazar better known as Babu, who was headed up to Camp I with oxygen bottles and other equipment. "I had to climb on. I had clients' gear. I had no trouble on the down-climb ladder. It was not broken at 6:34 a.m. when I went past. But there were inexperienced Sherpas waiting to climb down who were very slow."

Base Camp and the icefall were still in shadow, but far above, the summit haunts of the Sherpa gods were ablaze in light. Top to bottom it would be a beautiful morning on Everest—for **11 more minutes.**

"I had no chance to run"

So vast is the amphitheater of mountains around Everest Base Camp that climbers often see avalanches before they hear them. The sound follows like thunder after lightning, an oceanic hiss as cataracts of snow and ice and rock pour down steep gullies or over the lip of hanging valleys. But the avalanche of April 18 sounded different, especially to Sherpas who heard it while in the icefall itself. Almost all of them described it the same way: a deep *tuuung,* like the blow of a hammer against a muffled bell or a plucked string from some titanic bass.

A section of ice shaped like an enormous canine tooth, 113 feet tall and weighing 16 to 30 million pounds, exploded off the great ice mantle on the west shoulder of Everest and came hurtling down, fracturing into pieces and driving before it a wall of wind. As it gathered momentum and material, some Sherpas thought the avalanche took minutes to reach them; others said it struck in a matter of seconds. About two dozen climbers were directly in the path of the avalanche, and many others were at the margins above and below.

At 6:45 a.m. Kurt Hunter, the Everest Base Camp manager of Madison Mountaineering, was on a radio check with Dorje Khatri, the company's 46-year-old sirdar and a well-known union man who had unfurled different trade union banners each of the nine times he'd reached Everest's summit. Khatri had just gotten to the top of the triple ladders. Suddenly over the radio Hunter heard "shouting and yelling" and then "absolute silence." As the roar of the avalanche reached Base Camp directly, he dashed out of the communications tent to see the upper icefall consumed in a boiling cloud.

Hustling down for ten minutes, Nima Chhiring had reached the Football Field when the sound of the *tuuung* confirmed his worst fears. In seconds he was plastered in freezing rime, one of many survivors who staggered to their feet cloaked like ghosts in snow and ice. Pemba Sherpa, a young Everest veteran from the village of Phortse who had departed Base Camp at 4 a.m. on an acclimatization hike with a client from Alaska, had just reached the Football Field. Hit by a rush of wind, he looked up to see "a block of ice as large as a big house" bowling off the west shoulder. He bolted downhill with his client, and they threw themselves behind an ice formation as the sky was blotted out.

Karna Tamang, a 29-year-old guide with five Everest summits, had left Base Camp at 3 a.m. He was less than five minutes above the broken ladder when he heard the ***tuuung.***

"I had no chance to run," he recalled. "There



Ankaji Sherpa (above) displays Nepal's flag at the summit of Everest in 2012. The 36-year-old guide, mentor to many younger Sherpas, died in the April 18 avalanche. Bundled for transport, Ang Kami Sherpa (below) was one of three survivors flown from the mountain.

ANKAJI SHERPA (TOP), ANDY TYSON



About two dozen climbers were directly in the path of the avalanche. "I saw the ice coming, and I thought, We are gone. I am going to die."

was a shocking wind. To protect myself, I got down on my knees by a large block of ice and tried to save my face. I was covered by two inches of snow."

Babu Sherpa was about a minute above the broken ladder in a group of six Sherpas. "We huddled together. When the snow cleared, I looked down, and there was nobody below me," he said.

Fifteen minutes before the avalanche, Chhewang Sherpa, a 19-year-old working for New Zealand-based Adventure Consultants, had scraped through the section where the broken ladder had been. He was on his first Everest expedition and traveling with his brother-in-law, Kaji Sherpa, a 39-year-old father of three. Kaji clambered up a small ice cliff, secured to the fixed rope by his safety line. When the avalanche hit, Chhewang unclipped from the fixed rope and ran, and then crouched under his pack. As he later told his uncle Chhongba Sherpa, the Nepal-based director of the Khumbu Climbing Center, ice severed Kaji's safety line and knocked his brother-in-law unconscious. Chhewang was able to catch him and drag him to a safer spot. He poured a hot drink from Kaji's thermos, hoping to revive him.

"Kaji slowly woke up. He had a radio, I pressed the speak button because both of Kaji's arms were not working at all. He said, 'Please save me!' If I hadn't caught him, he would never have been seen again, because the crevasse was so deep."

Pasang Dorje Sherpa, a 20-year-old working for Seattle-based Alpine Ascents International, was climbing with two other AAI Sherpas, Ang Gyalzen and Tenzing Chottar. It was Pasang's second season on Everest. He was carrying a large dining tent pole, a thermos, and a coil of tent rope. When he heard the *tuuung,* he and Ang Gyalzen were about 45 seconds beyond the broken ladder—Tenzing Chottar only steps behind them. Tenzing, 29, was another Everest rookie. He had completed the basic and advanced mountaineering course at the Khumbu Climbing Center and was glad to have the job; he supported his elderly parents and had a three-month-old son. At Base Camp the day before, he had been able to call his wife, Pasi Sherpa, in Kathmandu.

"I saw the ice coming, and I thought, We are gone, I am going to die," Pasang Dorje recalled. "The wind was pushing me. I dived behind a big serac. If I hadn't been clipped into the fixed rope, I would have been swept away."

The ice slammed the tent pole against his head. It shattered his thermos and cut the rope. Flying ice punched a hole in Ang Gyalzen's down jacket. When the devouring cloud cleared two minutes later, the two Sherpas hugged each other, then looked around in horror. What had been a yawning chasm in the icefall requiring ropes and ladders to cross was now filled in with ice blocks as big as tables and couches. "Tenzing! Tenzing!" they shouted in vain.

Alerted by Michael Horst, a guide at Base Camp who saw the avalanche, Lakpa Rita, the sirdar for AAI, scrambled into his boots. He put a long antenna on his radio and tried to make contact with any of his staff traveling through

Chip Brown wrote about Brazil's Kayapo tribe for the January issue. Aaron Huey covered the Pine Ridge Reservation for the August 2012 issue.

the icefall that morning—33 climbing Sherpas, one cook, and two kitchen assistants. He finally reached Pasang Dorje, who told him maybe five or six Sherpas behind him were covered, and probably dead.

"I was very, very nervous," Pasang Dorje said. "I saw a Sherpa vomiting blood and a half-buried guy with his eyes all white, asking for water. We pulled him out. I don't even know his name. Most of my friends were crying."

"I tried to hide my tears"

Sherpas and western guides who had reached Camp I earlier headed down to help shortly after 7 a.m. At Base Camp, Lakpa Rita set off on the two-hour climb to the impact area with his brother Kami Rita, as did Horst, Ben Jones, Damian Benegas, and other guides. At Base Camp teams brought sleeping bags, shovels, and rescue equipment to the middle of the camp's three helicopter pads. Joe Kluberton, the AAI Base Camp manager, along with Caroline Blaikie and Mike Roberts of Adventure Consultants, began coordinating radio traffic. The airwaves were full of chatter as Sherpas confirmed their status. The number of dead was still unclear.

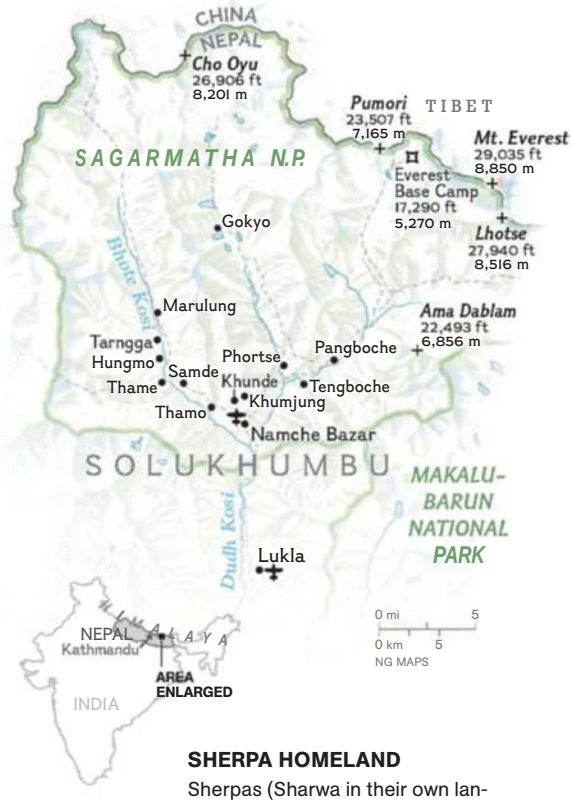
"We started to meet a lot of wounded Sherpas coming down," Lakpa Rita recalled. "They had bruises and blood on their heads. Some were limping from where they'd been hit by blocks of ice. I offered to help them, but they said, 'The guys up higher need more help than us.' I knew chances were nil anyone who had been buried would still be alive—they might have had 15 minutes at most."

It took Lakpa Rita almost an hour to get from the Football Field to the impact zone. Blood on the snow marked the area. He found about 50 Sherpas at the site, some digging with steel spades, some hacking at the debris with ice hammers, some sitting numbly in shock and grief. Four bodies had been placed under a gray tent fly. At the sight of the shrouded forms, Lakpa Rita sat and wept.

"I tried to hide my tears from my Sherpa team, but I couldn't keep them in," he said.

When he could look under the tent fly, he found that none of the dead were wearing the jackets AAI had issued its staff, and he set about helping the diggers. Two more corpses were freed from the ice, then another: Ang Tshiri, the cook. "Ang Tshiri was one of mine," he said.

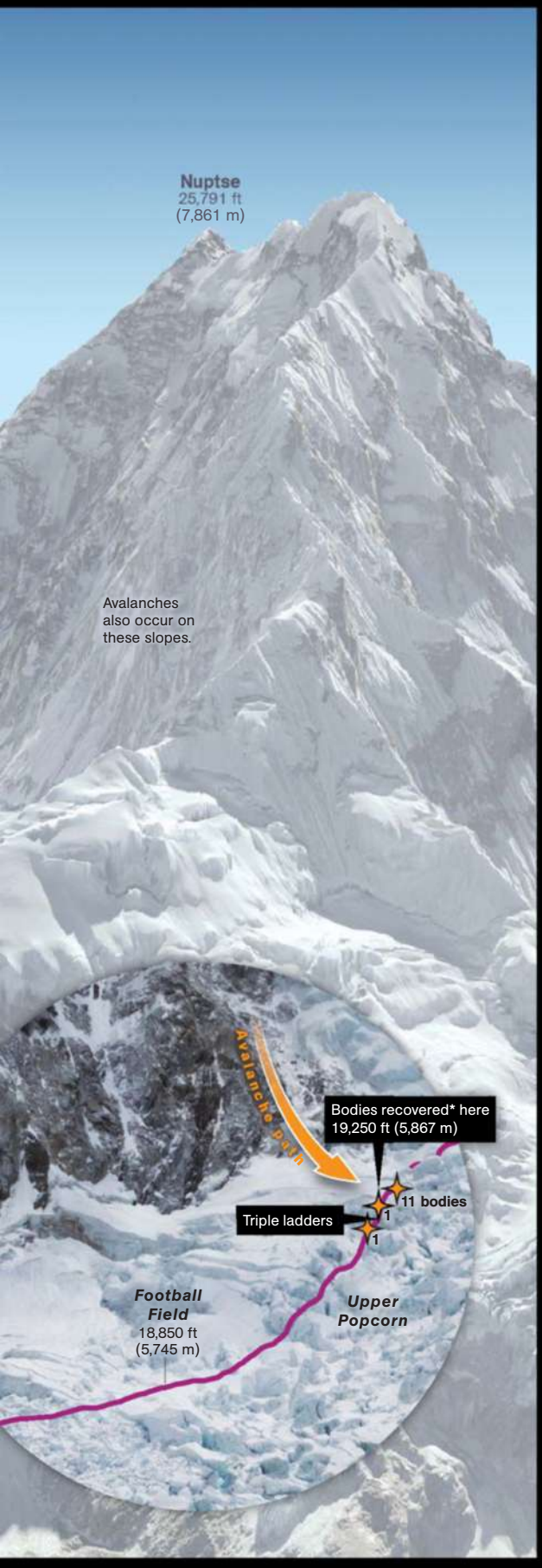
At Base Camp, amid a flurry of reports and rumors, tense radio traffic, and panicked phone calls, nine doctors from various expeditions gathered at the Himalayan Rescue Association clinic tent. Five climbers who had been strafed by ice were able to walk out of the icefall and eventually were treated at the clinic for bruises and lacerations. Three others would have to be evacuated by helicopter. At the impact site Damian Benegas started counting casualties and at 9:09 a.m. radioed that there were at least ten dead. Two Simrik Air helicopters piloted by New Zealander Jason Laing and Nepali Siddhartha Gurung arrived at Base Camp. Laing picked up the American mountaineer Melissa Arnot, a paramedic with five Everest summits; she delivered medical supplies to the rescue operation at 10:05. By 10:49 four Sherpas had been



SHERPA HOMELAND

Sherpas (Sharwa in their own language, meaning "people of the east") are believed to have migrated from Tibet into the valleys near Mount Everest about 500 years ago. The Solukhumbu District includes Everest, Cho Oyu, Pumori, and Lhotse, among other giant peaks.


MOUNT EVEREST SUMMIT
29,035 ft (8,850 m)
Lhotse
27,940 ft
(8,516 m)
West
Shoulder
23,980 ft
(7,309 m)
CAMP IV
25,938 ft
(7,906 m)
South
Col
Lhotse
Face
CAMP III
23,484 ft
(7,158 m)
CAMP II
Western
Cwm
CAMP I
19,800 ft
(6,035 m)
Serac band at approximately 20,200 feet, where the 16- to 30-million-pound ice block detached on the morning of April 18, 2014
Hanging
glacier
Avalanche path
2
1.75
1.5
Lho La
19,770 ft
(6,026 m)
Previous route through the Khumbu Icefall, which was more difficult to maintain this season
ACCIDENT SITE
(DETAIL AT RIGHT)
1.25
The
Popcorn
Khumbu Icefall
1.0
This season's route through the icefall
0.75 mile
to Base Camp
Khumbu
Glacier
SCALE VARIES IN THIS PERSPECTIVE.
VIEW IS TO THE SOUTHEAST.

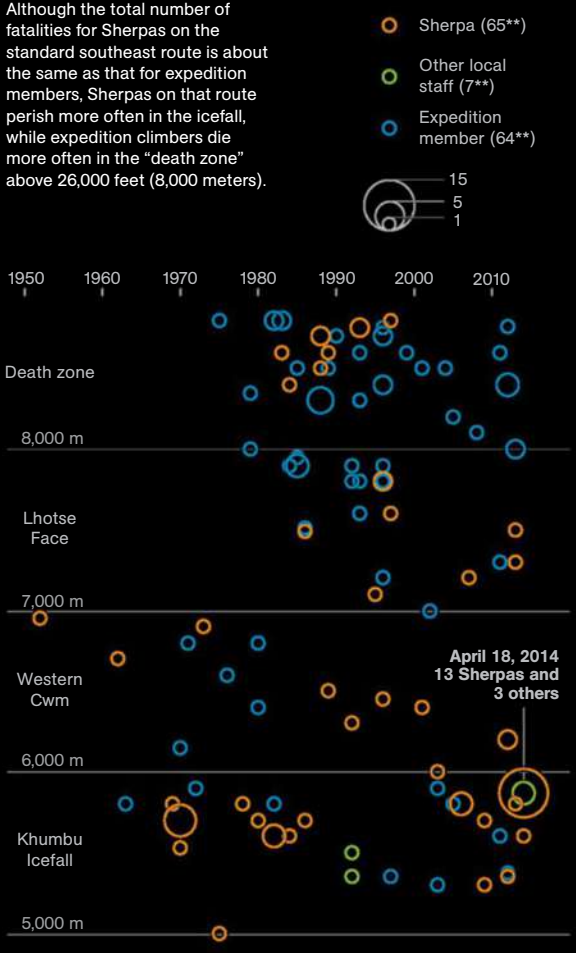


Fateful Day

At 6:45 a.m. on April 18, 2014, a massive section of ice calved off the hanging glacier on Mount Everest's west shoulder and roared a thousand feet down into the upper Khumbu Icefall, killing 16 mountain workers—13 of them Sherpas and three from other Nepali ethnic groups—and injuring eight. It was the worst accident in the peak's hundred-year climbing history.

WHERE SHERPAS DIE

Although the total number of fatalities for Sherpas on the standard southeast route is about the same as that for expedition members, Sherpas on that route perish more often in the icefall, while expedition climbers die more often in the "death zone" above 26,000 feet (8,000 meters).



* Three bodies have not been recovered
** Deaths below 16,400 ft (5,000 m) not shown

MARTIN GAMACHE, NGM STAFF; 3D REALITYMAPS. INSET PHOTO (4/16/14): ANDY TYSON

SOURCES: ANDY TYSON, ALPINE ASCENTS; DAVE MORTON, ADVENTURE CONSULTANTS; CONRAD ANKER, THE NORTH FACE; RICHARD SALISBURY, HIMALAYAN DATABASE; MICHAEL ROSS, RER ENERGY

helicoptered off the icefall with leg fractures; pelvic, abdominal, and head injuries; and internal bleeding. Among them was Kaji Sherpa, who was transported to a Kathmandu hospital with a punctured lung and two broken ribs. Shortly after 11 a.m. all the wounded had been evacuated to Base Camp, and the rescue teams turned to the task of recovering bodies. Twelve times, from 11 a.m. to 2 p.m., Laing hovered the red, black and silver Eurocopter AS350 B3e over the phantasmagoria of Everest's icy gateway and then veered off with a limp form dangling in boots and crampons at the end of a hundred-foot cable. The dead were delivered to the lowest of the Base Camp's landing pads, where they were numbered with pieces of duct tape and bundled into tarps. Sophie Wallace, expedition doctor for Adventure Consultants, sometimes had to throw herself across the bodies to keep the tarps from blowing off in the rotor's downdraft.

The identities of the victims were confirmed by teammates or sometimes by family members who also were working on the mountain. Uncertain of Ang Tshiri's fate, his son Pemba Tenjing had raced down from Camp I only to discover a pair of heartbreakingly familiar shoes. Dawa Nuru Sherpa, from the village of Samde (and a veteran of 13 Everest summits), knew Ang Tshiri was dead when he saw the cook's hand poking out of the snow. Their grandfathers were brothers, and he recognized the callus where his cousin had habitually brushed his left thumb against strands of yak wool he was twisting into thread.

The rescue workers were concerned that the west shoulder of Everest might unload again, and the grim work was suspended at 2:10 p.m., when afternoon temperatures made the icefall even more unstable. Crews would not be able to extricate Dorje Khatri's body, still partially encased in ice and hanging upside down in a crevasse above the triple ladder, until the next day. Three climbers were missing and presumed dead. All 16 of the deceased were Sherpas or workers of other Nepali ethnicities. They had died in harness, laboring to put their children through school, or to build a new house, or to buy asthma medication for elderly parents. Twenty-eight children had lost their fathers. Eleven of the dead had been killed in one place—the sloping ice ledge where they were waiting to descend

WORKING ON THE MOUNTAIN

High-altitude workers—mostly Sherpas, but also those of other ethnicities—tend to the needs of the hundreds of climbers who visit Nepal each year with commercial expeditions. Their roles vary in pay and prestige.

SIRDARS
They oversee all staff and client services and sometimes work above Base Camp. An expedition depends on their experience and management abilities.
Pay per season*: $5,000

HIGH-ALTITUDE GUIDES
This group fixes ropes and guides clients to the summit. They mostly are experienced climbers who have climbed Everest or other peaks.
$4,500–$5,000

GOVERNMENT LIAISON OFFICERS
Stationed at Base Camp, they relay an expedition's progress to the tourism ministry and work with expedition leaders to minimize impacts to the mountain.
$3,500

ICEFALL DOCTORS
This group installs and maintains ropes and ladders in the ever shifting Khumbu Icefall. Often older and experienced, they can no longer climb higher or choose not to.
$2,000–$4,000

SUPPORT GUIDES
They establish, supply, and maintain lower camps and the routes between them. They are often less experienced than other support personnel or have insufficient foreign language skills to communicate well with clients.
$1,700–$2,500

KITCHEN STAFF
They carry kitchen equipment to Base Camp and maintain the cooking operations there and at some lower camps.
$1,200–$1,500

*ESTIMATED AMOUNT FOR 40 DAYS' WORK AT BASE CAMP OR ABOVE

NGM ART. SOURCES: RICHARD SALISBURY, HIMALAYAN DATABASE; TENZING TASHI SHERPA; MURARI K. SHARMA; STAN STEVENS, UMASS AMHERST

the now obliterated down-climb ladder.

"I believe they tried to escape, and when they realized they couldn't, they huddled together," Lakpa Rita said. The horror of the day had surpassed all previous accidents on Everest, including the catastrophes of 1922, 1970, and 1974, when Sherpas had also died in groups. And yet the impact of it was only beginning to unfold.

A tense debate

THE DAYS AFTER THE AVALANCHE were a chaotic mix of pujas, funerals, meetings, questions, rumors, demands, provocations, and epiphanies. Would the climbing season continue? Should it? How long was long enough to mourn? Russell Brice of Himalayan Experience and Eric Simonson of International Mountain Guides gave their large Sherpa teams leave to go home for four days. Not all of them wanted to come back. One Sherpa outfitter reported that a wife had threatened suicide if her husband returned to the mountain.

Lakpa Rita knew immediately the climbing season was over for AAI—he could not ask Sherpas he had hired to resume when they had lost five teammates and bodies were still buried in the ice. Sherpas on other teams said they would continue but began to feel pressured by activists who saw the tragedy as a chance to press for improvements to the mountain guides' working conditions. Many Sherpas were infuriated when the Nepali government offered each victim's family about $415 compensation, money that wouldn't even begin to cover the cost of a funeral.

Numerous people have noted a new assertiveness among the younger generation of Sherpa guides and workers, particularly after last year's so-called brawl, in which three well-known European climbers got tangled up with a Sherpa rope-fixing team above Camp II. In the days after the avalanche, labor tensions that had been hinted at a year ago came fully into view when angry, grieving Sherpas effectively unplugged the Nepali government's multimillion-dollar Everest cash machine, which annually brings the government more than $3 million in permit fees and ancillary economic benefits estimated by foreign expedition operators at more than $15 million. As one Sherpa blogger in Kathmandu said of the tragedy: "The things we couldn't change showed us the things we could."

They died in harness, laboring to put their children through school, build a new house, or buy asthma medication for their elderly parents.

On Sunday, April 20, two days after the avalanche, expedition leaders, rescue workers, and people affected by the accident met in the tent of the Sagarmatha Pollution Control Committee (SPCC), a locally run nonprofit organization that oversees the Icefall Doctors and garbage management on Everest. Among the outspoken Sherpas attending were Nepal Mountaineering Association board member Pasang Bhote and Pasang Tenzing, a 29-year-old with ten Everest summits who was an assistant expedition leader for the British company Jagged Globe. Out of the meeting came a list of 13 demands for government officials. Among other things, Sherpas sought increased insurance coverage and a bigger slice of Everest permit fees to pay for a fund that would support the families of mountain workers killed or injured in the future.

On Monday, April 21, emotional images

of the Sherpa funerals in Kathmandu were broadcast around the world, and the next day a giant puja attended by 22 lamas was held at Base Camp. Afterward the bill of demands was read aloud in Nepali and English. Tensions were building. Some people in the crowd shouted that they didn't want to climb. "It was clear to me that the majority of workers simply wanted to just go home in respect for the dead and for their own safety," wrote Sumit Joshi, founder of Himalayan Ascent, a Nepali-owned firm. Western expedition bloggers described the meeting as having been "hijacked by militants and turned into a political rally." Base Camp was roiling with talk of a boycott and threats by "Maoists" and "militants" against anyone who disagreed. Meanwhile, the Ministry of Culture, Tourism and Civil Aviation was predicting that "all climbing activities will surely resume in a day or two."

It wasn't until Thursday, April 24, six days after the avalanche, that Nepali government officials finally showed up at Base Camp. The 12-member delegation led by Bhim Prasad Acharya, the head of the tourism ministry, helicoptered in at 9 a.m., hoping to persuade Sherpas to return to work. In a follow-up report, Brice, among Everest's most senior foreign operators, wrote that he was told some Sherpas had thrown rocks and tried to prevent the delegation from departing in the helicopters when the meeting was over. Repeating another of the rumors swirling around, Brice also wrote that Sherpas had turned off the supplemental oxygen of a delegation member unacclimatized to altitude, an allegation in keeping with the fraught atmosphere in the days after the avalanche but one roundly disputed by Sumit Joshi: "Someone from the crowd did crack a joke about turning the oxygen off to let him know how it feels to be at that altitude. I am almost definite it did not happen."

Others suggested that the people making threats were not even part of the climbing community. "They were all young and unfriendly," said John All of the American Climber Science Program. "Their jackets were lighter and cleaner than typical Everest Base Camp gear, and no one could remember seeing them in camp before the avalanche. We all thought, Who are these guys?"

As the Nepali officials were leaving, the glacier on the west shoulder calved again, and a small avalanche rumbled into the icefall precisely where the 16 men had died. Many took it as the final sign from the deities that the 2014 spring climbing season on Everest was over.

"What makes us different"

It's difficult to parse the reports, rumors, and conflicting impressions of what happened at Base Camp after the avalanche. A lot of Sherpas who didn't want to climb, out of grief and well-founded concern about the condition of the icefall, may have found it easier to beg off by saying they were discouraged from climbing by threats from "militants." Without countenancing violence, one has to wonder, Why shouldn't mountain workers seek to empower themselves and use hard-won leverage to improve their standing? Few Western commentators considered the so-called Sherpa strike in the larger context of Nepal itself, where strikes—*bandhs*—are staples of everyday life and one of the only means of getting the government bureaucracy to pay attention. While the labor issues on Everest were being sorted out, road crews expanding streets in Kathmandu had to stop because the gravel industry was on strike.

"Twenty years ago, less than 50 percent of the workers on Everest had finished high school," Sumit Joshi estimated a month after the avalanche. "Now 80 percent of Everest workers have graduated from high school. They've been exposed to Western media. They know how things work. They are more aware of their rights. They know they can speak their mind. They know about the outside world and how much money the government gets from permit revenue and how little of it comes back to them. They shouldn't be branded militants or Maoists or a new breed. It's not a new breed; it's a younger generation."

The generational shift is not only producing Sherpa climbers who are more aware of the outside world, it is also changing the mix of ethnicities on the mountain. What was almost an exclusively Sherpa labor force is now increasingly staffed by ethnic groups such as the Rai and Tamang, who often are much poorer and desperate for work. Of the 17 "Sherpas" on John All's expedition, 5 were ethnic Sherpas; 12 were Rai or Tamang. "Sherpas are still the tip of the spear,



Death on the mountain touches many Sherpa families. Stricken by the loss of her father, Ankaji Sherpa, Chhechi Sherpa (above) is comforted in Kathmandu. For Nima Doma Sherpa (below) of Pangboche, memories of her husband, DaRita Sherpa, are still tender. He left behind two young daughters when he died on Everest in 2013.

NIRANJAN SHRESTHA, AP IMAGES (TOP)



One gets the sense that Sherpas feel they can't afford to tarnish how outsiders idealize them as peaceful and unselfish.

doing most of the work above 7,500 meters," All said, "but Rai and Tamang mountain workers now commonly carry loads to Camp III."

When I asked SPCC chairman Ang Dorjee Sherpa about the rumors of Sherpas threatening other Sherpas, he was quick to play them down. One gets the sense sometimes that the Sherpas themselves, so long esteemed for the better angels of their nature, feel they can't afford to tarnish the ways in which outsiders idealize them as the peaceful, unselfish inhabitants of an idyllic mountain land, far from the perturbations of modernity.

"You have to understand the culture," Ang Dorjee said one afternoon in the Panorama Lodge in Namche Bazar. "It's perfectly normal for us to say you are going to break someone's legs, as long as you don't actually break them. Every year there are four or five fights during the Dumchi festival in Namche. It's normal for us to exchange blows while drinking chang, and then tomorrow we're friends again, and everything is fine. Ninety-nine percent of Sherpas are very loyal and honest and hardworking. That tradition is carrying on. If we lose that tradition, then we will have a problem. Anyone can be a good climber, but being honest and loyal and hardworking is what makes us different."

Into the villages

The havoc of the avalanche that buried 16 men did not stop in the icefall. It barreled on—into the villages under Everest and beyond. In Kathmandu the office manager of Himalayan Ascent called Chhechi Sherpa, the 19-year-old daughter of Ankaji Sherpa, with the news that her father had been killed, sparing the detail that the veteran guide's helmet had been split open. Ankaji had promised to watch out for Pem Tenji Sherpa, a 20-year-old Everest rookie who was married to his niece; he'd helped Pem Tenji get the gig that season as a Camp II kitchen assistant—a job considered among the safest because it required only one round-trip through the icefall. But Pem Tenji had also been killed, and his wife, Dali, did not even have a body to mourn; her husband was still entombed somewhere in the icefall.

During the Kathmandu funerals for six of the avalanche victims, there was no more poignant emblem of loss than the pictures that flashed around the world of Chhechi's crushed expression and of Ankaji's 76-year-old mother, Nimali, her face knotted in the anguish of a mother who has outlived her son. In Khumjung the widow Ngima Doma heard the news from a teahouse television and knew her husband, Lhakpa Tenjing, was among the dead when she came home and found her in-laws weeping.

"I'll never put on crampons again," said Lhakpa Tenjing's older brother Nima Sherpa, who might have died had he not left Base Camp a week before the avalanche to have a throat infection treated in Kathmandu.

For his part, Nima Chhiring, the man with the crying ear, wasn't eager to return to Everest next season but didn't see any choice. He didn't have much education, and now he had a wife, two kids, and no house of his own or money to pay for schools. He would be heading off from Khumjung soon to tend the five yaks he'd bought in 2009, but he wondered if the hard

times would ever relent. "I need help," he said. He asked if there were any benefits for Sherpas who hadn't died in the avalanche, and when he heard there weren't, he seemed for a moment almost to rue the luck that condemned him to live.

And then there was poor Chhewang Sherpa: He walked four days from Everest Base Camp to his home in Nunthala, the last morning in a heavy storm with torrential rain, hail, thunder, and lightning. He had taken off his wet shoes, and around noon, on May 1, 13 days after the brush with death that left the teenager overjoyed to be alive, he was approaching his parents when he was knocked to the ground by a bolt of lightning. Another bolt hit nearby and killed him.

In Thamo, Ang Tshiri's son, Pemba Tenjing, had phoned his mother with the news from Everest. The mountain that killed his father, the veteran expedition cook, was proudly featured on the sign outside the family's restaurant. Ang Tshiri's relatives, friends, and a monk carried his body home from Namche. In similar fashion Mingma Nuru was brought back to Phurte, where his mother mourned the second of her sons to die on Everest. It was Pemba Tenjing's family who dispatched a boy to hike three hours up the Bhote Kosi valley to Tarngga to inform Ang Nemi that her husband, Dorje—Ang Tshiri's half brother—was dead on Everest.

Dorje and Ang Nemi had been married 14 years. They had two girls and two boys, all born in yak-herding huts. They lived year-round at 13,000 feet; most of the dozen or so other families came there only in the summer to pasture animals. They had almost nothing: a potato field, some yaks they used to ferry loads to Everest, and the dark-as-a-cave, one-room house Dorje's father had built, a stone house with a stone roof ringed by stone walls in country that was a plague of stones. The children slept on bedding Ang Nemi rolled out nightly on benches, and they sometimes dawdled on the long walk home from school to play jacks with small stones. For five years Dorje had been working on Everest for Alpine Ascents International; he'd been a cook at Camp IV on the South Col. He and Ang Nemi were saving the wages to build a house closer to Thame so it would be easier for their kids to get to school. They had picked out a site below the monastery in the village of Hungmo.

Uncertain where Dorje's body was after she got word on April 18, the new widow hurried two hours down to Thame to use a telephone. AAI would be bringing Dorje's body to Tarngga, she learned, so she walked home and waited. But the body didn't arrive, and the next morning, she hiked to Thame again to see what the delay was. Around 9:30 a.m. she saw the helicopter flying by.

It landed in a potato field near the house. AAI owner Todd Burleson and Lakpa Rita and Pemba Tenjing carried Dorje inside. Seeing their father in the butter-lamp light, wrapped in a blue tarp, still in his mountain clothes and boots, the kids began to cry.

Six-year-old Da Jangbu didn't understand what was happening, but his 12-year-old sister, Mingma Doma, had an idea.

"What happened to my father?" she asked. Lakpa Rita said later that he didn't know what to say.

"I am so sorry," Burleson said. "I don't know what happened."

All four kids sobbed and held on to the pallbearers; they were weeping too, but they had other bereaved families to console and hard errands ahead, and after 15 minutes the helicopter took them away.

You'll hear it said that there are some glimmers of light arising from Everest's darkest day. The Sherpa Education Fund, set up by Alpine Ascents in 1999, arranged for Dorje and Ang Nemi's children to attend the Shree Himalayan Primary School in Namche Bazar. The fund also paid for them to move from their wintry hovel on the margins of the habitable world to the Home Away From Home, a spacious light-filled hostel bustling with 57 other kids their age and just a hop and a skip from school. Suddenly, a month after the avalanche, they had packs of new friends, varied meals, blue parkas, school uniforms, toothbrushes, real beds to sleep in under the cockeyed gaze of a Cookie Monster doll, and prospects they could scarcely have imagined. All it had cost them was their father. □

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Sizing Up the Disaster

Read our extensive news coverage of the avalanche and get a breathtaking satellite view of the ice block—estimated to be taller than two stacked buses.

VIDEO



SHERPA PRIDE AND SACRIFICE

Some brandish ice axes at the summit. Others hold up flags, family photos, or prayer cards given to them for protection. Snapshots like these by Sherpa climbers line the walls of teahouses and homes all over the Everest region. Although the climbing industry has taken a heavy toll on Sherpa families, it has also brought income and opportunity. Once poor, isolated villages of farmers and traders have been transformed into relatively prosperous, educated communities of Nepalis at home both in the mountains and in the modern world.

IMAGES COURTESY SHERPA CLIMBERS; PHOTOGRAPHED BY AARON HUEY



PASANG LHAMU SHERPA



SONAM TASHI SHERPA



PHUTASHI SHERPA



PANURU SHERPA



PEMBA SHERPA (AT LEFT) AND PENSA G. SHERPA



TENZING GYALZEN SHERPA



DA NURU SHERPA



PEMBA G. SHERPA



PEMBA NURU



TENZING GYALZEN SHERPA

NURU GELJEN SHERPA



TENZING DORJEE SHERPA









Da Nuru Sherpa coils rope at Camp II on Ama Dablam, perched like a spectacular bird's nest at 19,600 feet. Carrying gear from a high camp on Everest, Sonam Dorji Sherpa (far left) exits the Khumbu Icefall.



Lakpa Sherpa replaces rope from the previous year between Camp I and Camp II on Ama Dablam. Climbers with commercial groups will use the fixed rope to help them ascend the peak.





ESSENTIAL TASKS

Climbing Sherpas are part guide, part porter, part personal assistant, part coach, and part guardian. Duties can include hauling gear (above) or serving breakfast in bed (top right). How high their stack of money will be on payday (right) often depends on how much weight they've carried and how many trips they've made between camps. Western companies generally pay better than Nepali-owned ones. Besides paying for education and other necessities, wages from the mountains are invested in yaks, houses, and businesses such as tourist lodges.









At the annual Dumchi festival in Phortse, grieving parents Phu Dorji and Phura Yangi are honored with *khata*, ceremonial scarves, in memory of their son, DaRita Sherpa, who died of high-altitude-related causes on Everest in 2013.



A special rice dish is offered to villagers during the Dumchi festival in Phortse. Expedition-style jackets are another sign of climbing's influence on Sherpa life.





BACK HOME

Once the climbing season is over, Sherpa mountain workers quickly return to village life. In Phortse, Da Nuru Sherpa (top right), who has summited Everest 16 times, shares a laugh with his mother, Daki Sherpa, at her home. Eight of Daki's sons have worked as mountain guides. Karma Tshering Sherpa (right) once helped Edmund Hillary build schools in the Khumbu region. Today he lives next to his son, who guided on Everest, and grandchildren. Elders (above) attach prayer flags outside Phortse at an altar for Khumbila, the god of the Khumbu.


RAMBA





With money made in the mountains, Sherpas often send their children to boarding schools in Kathmandu in the hope that those of the next generation won't have to risk their lives on Everest.





Lowcountry Legacy

Rice planters made royal fortunes here in centuries past. Now South Carolina's ACE Basin harbors a wealth of wildlife and history.



A moss-hung cypress keeps watch over the placid waters of the ACE Basin, named for three rivers that run through it: the Ashepoo, Combahee, and Edisto.





Water—fresh, brackish, and salt—is the lifeblood of the basin. Along the Combahee River, wetlands veined with tidal creeks are nurseries for fish and feeding grounds for birds. Visitors in boats often spy bald eagles.

By Franklin Burroughs
Photographs by Vincent J. Musi

When I was growing up in South Carolina, the oldest places I knew were also the wildest places.

History and natural history cohabited in the antebellum rice-field country and the barrier islands, which began 35 miles south of Conway, where we lived, and stretched past Georgetown and Charleston and on to the Georgia line. History had populated these places, then depopulated them. Their sense of vanished human presence and their teeming life—fish, flesh, and fowl, to say nothing of snakes, sea turtles, and alligators—gave rise to two rumors. One was that cougars still lurked in the deepest swamps. The other was that ghosts hung around particular plantations. Reliable people saw unaccountable things. That is what other reliable people told you, and what you secretly wished to believe.

I left South Carolina more than 50 years ago. Since then, history has repopulated much of that old country. There is a new prosperity, a new and glittering worldliness. Before I left, I'd heard about Kiawah Island, a big, history-haunted place I dreamed of getting to. Its sea island cotton plantations were long gone, and by my standards, it seemed a sort of paradise—miles of empty beach on one side, miles of salt marsh and tidal creek on the other, separated by a jungle of second-growth maritime forest.

A few years ago I got to see Kiawah for the first time. I chartered a plane to fly me from Charleston 20 miles south to the ACE Basin, a relatively intact and exceptionally rich ecosystem fed by the Ashepoo, Combahee, and Edisto Rivers. We passed over Charleston Harbor—Fort Sumter, ugly as a wart, just below us; to the west the skyline of the old city—and soon had Kiawah in sight.

"They had the Ryder Cup there in 1991," the pilot told me,



Young J. D. Cate takes a break following an early morning duck hunt with his father and the family's retriever, Henry. Hunting waterfowl and other game is a cherished tradition in the basin, spanning generations and spurring conservation efforts.

gesturing toward a golf course at the north end. "I watched some of it and got to look around Kiawah. Man, that place is paradise, if you're rich enough."

The golf course, the nicely landscaped neighborhoods of the interior, and the long, wide beach truly were beautiful, lying quietly in the soft light of a spring morning. But this was a different fantasy of paradise. No hope of seeing a cougar here, though Tiger Woods was a possibility, I supposed.

After a long history of comparative neglect, during which nature reclaimed much of the island, Kiawah now has 3,500 housing units, two luxury hotels, an international clientele, and a new identity based on tourism and residential development. What happened to it has happened all along the Atlantic coast to places I have unconsciously considered sacred, like churchyards or battlefields, places protected by their history from history itself.

As waterfront property has grown ever scarcer and more valuable, and strip malls, housing developments, and upscale Elysiums like Kiawah stretch southward from Charleston, the ACE Basin has grown ever more anachronistic economically and ever more indispensable biologically. The effort to protect it began 25 years ago, when crucial habitats were identified, their owners approached. An alphabet soup of agencies, foundations, and nonprofit organizations—some national, some local—was enlisted. As

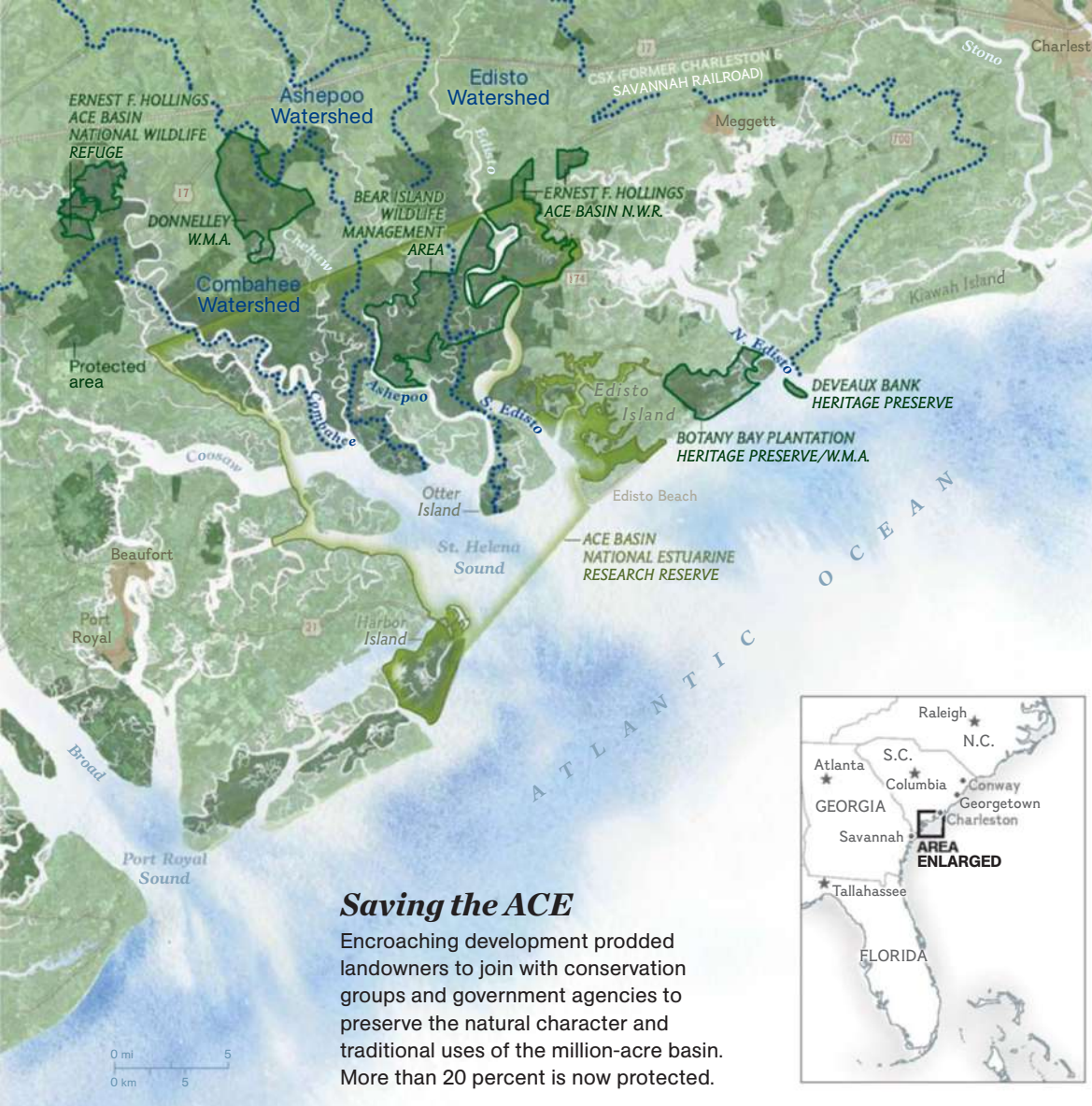
Franklin Burroughs's latest book is Confluence: Merrymeeting Bay. *Photographer Vincent Musi lives near Charleston, South Carolina.*

currently delineated, the ACE Basin consists of roughly 1.1 million acres of upland, marsh, diked wetland, and coastal islands. Approximately 200,000 acres are protected—some sold or donated to public agencies, and some remaining private but with conservation easements that preclude subdivision and development.

The basin is an archipelago of low islands, separated and veined by a maze of winding creeks, rivers, marshlands, and swamps. Flying over the region, I saw just two-lane roads, many of them unpaved and visible only when they emerged from the canopy of the woods to cross marshes or rivers on causeways or bridges. A few modest houses were scattered along the roads, and there was a dock with a couple of trawlers tied up to it and a public boat launch near the mouth of the Ashepoo. It looked more like the South Carolina I had heard my father describe than the one I had rummaged around in half a century earlier.

This landscape took shape well before the American Revolution, molded by the history of rice cultivation in the region. The earliest method of rice planting involved damming narrow swamps and using the impoundments, called reserves, to flood the fields below them at the appropriate time. A later, more elaborate system depended on tidal fresh water; it worked only in the narrow region that was far enough upriver to be beyond the reach of salt water but far enough downriver to have significant tides. Swamps were diked off from the river and cleared. Then ingenious, double-gated spillways called trunks were installed in the dikes. These were used to exclude the tides for plowing and planting, then flood the fields to precisely regulated levels as the rice grew. In September the fields would be drained for harvesting. This system allowed for cultivation on a vast scale and generated great wealth for many of the planters.

Even by South Carolina standards, the Lowcountry planters were ardently secessionist, and they paid for it in the Civil War. Federal troops quickly gained control of several barrier islands. The planters lit out for the interior, leaving their plantations to be burned and their slaves to be emancipated by Federal gunboat crews and raiding parties. After the war one planter returned to find what he described as a "howling wilderness"—the dikes broken down, the ditches clogged and overgrown. Cordgrass, cattails, needlerushes, and bulrushes completed the conversion of tillage land into marsh. Wildlife flourished in these disimproved places, and wealthy sportsmen, many of them Yankees, bought up the old plantations. To the extent that they maintained the rice fields and the uplands, these new owners did so for the sake of deer, quail, turkeys, doves, and especially ducks. They spent their winters pursuing those creatures, living sometimes in plantation houses that had managed to survive the war, sometimes in houses they themselves built, often on the site of the original house.



Saving the ACE

Encroaching development prodded landowners to join with conservation groups and government agencies to preserve the natural character and traditional uses of the million-acre basin. More than 20 percent is now protected.

Decades have passed, and the new prosperity has established itself, leaving the ACE Basin as a functioning historical landscape. Hunters, fishermen, and bird-watchers avail themselves of its four state-owned wildlife management areas. One, at Bear Island, is predominantly restored rice fields; another, Donnelley, is primarily upland, although it includes several hundred acres of old rice fields and a beautiful reserve. On this March day most of the fields across the basin had been drained, and tractors were at work on several. Corn is the primary crop. The fields remain dry all summer and are flooded in the fall, with the unharvested corn still standing. Ducks harvest the corn; hunters harvest the ducks.

Dean Harrigal, who oversees the ACE for South Carolina's Department of Natural Resources, took me to Otter Island, one of its many gems. He spoke of the Civil War fortifications that lay somewhere in the dense growth of the interior: a battery established by the Confederates in 1861, seized by Federal forces the same year,

MARTIN GAMACHE, NGM STAFF; ROB WOOD
SOURCES: SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES; U.S. FISH AND WILDLIFE SERVICE



Skeletons of live oak remain visible as high tide claims a “boneyard beach” on Edisto Island. Erosion is a natural part of a barrier island’s life cycle.











"The ACE Basin is a big jigsaw puzzle," says wildlife biologist Dean Harrigal of its many habitats. Wetlands provide feeding and resting areas for waterfowl, seen here through grasses (left, top). Wading birds, mink, and alligators live in tidal marshes (middle). Land managers use controlled burning (bottom) to remove unwanted vegetation, stimulate fresh growth, and release seeds for wildlife.



and turned into a signal station. A colony of self-emancipated slaves grew up around it. No sign of these things, or of any other human enterprise, remained, but we did see whimbrels, godwits, willets, oystercatchers, red knots, dunlins, and plovers. Their cries, the thumping and sighing of the surf, the rattling of the wind in the palmettos, and the squeak of sand underfoot were the only sounds. The place could have been waiting for Robinson Crusoe to stagger ashore and for its history to begin.

Back in the woods, on a slight knoll overlooking the Chehaw River, a tributary of the Combahee, were several low burial vaults under an ancient, collapsing live oak. The surrounding trees were big and widely spaced—a magnolia, a beech, a holly, a walnut. "Those trees were planted," Harrigal said. "You don't find them growing in the same spot like that naturally. Somebody wanted this to be like an arboretum. And that little ditch along the edge of the marsh? I think it was a small canal, big enough to float the crops down to the river. There was a whole life here."

Farther down the Chehaw, another vault, quite a fine one, dating from before the Revolution, stood in front of the overgrown earthworks of a Confederate battery, built to protect a bridge on the Charleston & Savannah Railroad a little farther upriver. Behind the earthworks, scattered in low woods, were the tombstones of slaves, former slaves, and their descendants; a spare cinder-block church, still in use, was half a mile away. "Whenever we sign an easement or a property transfer," Harrigal said, "I tell people that with one stroke of the pen we're preserving our heritage and our environment. It's a good line. And it's the truth."

You can stand on one of the dikes in the Bear Island Wildlife Management Area and imagine that a chunk of Holland had been set down in the New World. There is only one decrepit windmill here and not many people, but there is a greater variety, abundance, and obviousness of animal life than I have seen anywhere else in North America. In one canal beside a dike I counted over a hundred alligators, most of them still as stumps. Black skimmers, flying low and straight, their lower mandibles shearing the water, lifted over the motionless heads as casually as a man stepping over a log. About 500 storks, ibis, egrets, and white pelicans stood along the bank, as though waiting for a parade to start.

Driving by a small, diked, mostly drained former rice field in the Donnelley Wildlife Management Area, Harrigal stopped the truck and handed me his binoculars. "Look out there and tell me what you see," he said. I glanced and saw the usual suspects—herons, a glossy ibis, and even an immature eagle standing on the mud. Close to the eagle were two big white birds. They walked with a stoop, but they weren't storks. Or egrets. Or ibis. I raised the binoculars and stared, then handed them back to Harrigal and said I did not believe it. A pair of whooping cranes.



Palmettos succumb to the sea at Botany Bay Plantation, a favorite stop for bird-watchers, fishermen, and nesting sea turtles. As the tide of development claims more and more coastline, the value of the ACE Basin—to people as well as to wildlife—grows.

When I was a boy, there were fewer than two dozen of them on Earth. Now there are five or six hundred. The last time one had been seen in South Carolina was 1850. Then this pair appeared. Seeing them in this place suggested natural possibilities that seemed almost supernatural.

But Harrigal was adamant about one of those possibilities, and so was every other wildlife biologist I met down there. "I don't care what you hear or who you hear it from," he said. "There are *no cougars* in the ACE Basin. Elvis? Maybe. UFOs? I wouldn't rule it out. But cougars? No. No way."

So sure enough, back home in the deep North, I'm chatting with a friend. He's originally from Charleston, knows the ACE Basin. He's a reliable, skeptical fellow, and a wildlife biologist himself.

It wasn't him. It was his cousin, whom he'd vouch for, even though it happened late at night and the cousin was tired. He was slowly driving down an oak-lined avenue that led into one of the plantations, where he was visiting. The thing materialized out of the woods, loped down the road ahead of him, in no great hurry. He knew what bobcats look like. Also what dogs, foxes, coyotes look like. This animal was big, very long tailed, and about the color and consistency of smoke. It turned, eyes glittering in the headlights, then bounded into the shadows.

The evidence of one kind of faith is the evidence of things not seen or half seen.

The evidence of another kind of faith is fact: the ACE Basin itself. □

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Is America's appetite for meat bad for the planet?

Unhealthy. Nutritious.
Cruel. Delicious.
Unsustainable. All-American.
In the beef debate there
are so many sides.

Carnivore's Dilemma

By *Robert Kunzig*

Photographs by *Brian Finke*



In Amarillo, Texas, a patty-forming machine at a Caviness Beef Packers plant cranks out 24,000 half-pound hamburger patties an hour for the restaurant trade. Individual Americans eat 40 percent less beef now than in the peak consumption year, 1976, but there are many more Americans. Today the United States remains the world's largest consumer and producer of beef.





If Isabella Bartol (at far right) had her druthers, she'd eat a burger every day. Isabella, nine, prefers just ketchup on her cheeseburger; sister Betsy, four, puts everything on hers. At P. Terry's Burger Stand in Austin, Texas, "all natural" burgers—made from cattle that never received hormones or antibiotics—cost only $2.45. Americans eat a lot of meat but still spend just 11 percent of their income on food, less than people in many other countries.



FOOD

At Wrangler Feedyard, on the High Plains of the Texas Panhandle, night was coming to an end, and 20,000 tons of meat were beginning to stir. The humans who run this city of beef had been up for hours. Steam billowed from the stacks of the feed mill; trucks rumbled down alleys, pouring rivers

of steam-flaked corn into nine miles of concrete troughs. In one crowded pen after another, large heads poked through the fence and plunged into the troughs. For most of the 43,000 cattle here, it would be just another day of putting on a couple pounds of well-marbled beef. But near the yard's north end a few hundred animals were embarking on their final journey: By afternoon they'd be split in half and hanging from hooks.

Meat is murder. Meat—especially beef—is cigarettes and a Hummer rolled into one. For the sake of the animals, our own health, and the health of the planet, we must eat less of it.

Meat is delicious. Meat is nutritious. Global demand is soaring for good reason, and we must find a way to produce more of it.

In short, meat—especially beef—has become the stuff of fierce debate.

People can't settle that debate for others—Americans, say, can't decide how much beef or other meat Chinese should eat as their living standards improve. But each of us takes a personal stand with every trip to the supermarket. Critics of industrial-scale beef production say it's warming our climate, wasting land we could use to feed more people, and polluting and wasting precious water—all while subjecting millions of cattle to early death and a wretched life in confinement. Most of us, though, have little idea how our beef is actually produced. Last January, as part of a longer journey into the world of meat, I spent a week at Wrangler, in Tulia, Texas. I was looking for an answer to one fundamental question: Is it all right for an American to eat beef?

And so at 6:45 on a Tuesday morning I was standing with Paul Defoor, chief operating officer of Cactus Feeders, the company that operates Wrangler and eight other feed yards in the panhandle and in Kansas. Cactus ships a million head of cattle a year; Defoor and I were watching a few dozen get on a truck. The temperature was in the teens. The cattle were steaming as cowboys on horseback and on foot herded 17 of them—enough to fill one deck of the 18-wheel double-decker truck—down an alley of fences. The animals couldn't know where they were headed; still, at the top of the ramp the lead steer stopped and wouldn't enter the truck.

"One or two days a week there are a couple of hours that are a little tough," said Defoor. "You have to want to do this."

A few deft maneuvers from a cowboy, and within seconds the cattle jam dissolved. More than ten tons of live freight surged onto the



Beef is big in Texas. Last year in the state, ten times as many calves were born, 3.85 million, as human babies. At the Big Texan in Amarillo—which offers free rides in a longhorn limo—you get your 72-ounce steak for free if you finish it in under an hour, along with the shrimp cocktail, the baked potato, the salad, and the roll.

truck's top deck, then another ten filled the lower deck. The truck shook. Dust poured from the slits in its sides. The driver shut the rolling door, climbed in the cab, and took off across the yard.

Defoor and I followed in his pickup. In the pen that had been these animals' last home, road graders were already scraping five months' worth of manure off the hardpan. By the time we got to the front gate, the truck was disappearing toward Interstate 27 and the Tyson packing plant outside Amarillo. We raced after it. Behind us the sky was just starting to turn pink.

"If you call a meal a third of a pound of lean beef," Defoor said, "then one of those animals you saw getting on the truck will make 1,800 meals. That's amazing. You're looking at 60,000 meals on this truck ahead of us."

CACTUS FEEDERS, which is headquartered in Amarillo and owned now by its employees, was co-founded by a cattleman from Nebraska named Paul Engler. In 1960, the story goes, Engler came to the area to buy cattle for a Nebraska feedlot and realized the panhandle was

Photographer Brian Finke is a Texas native; this is his first article for National Geographic. *Robert Kunzig is the magazine's senior environment editor.*





Cowboys prepare to tag and vaccinate a month-old calf at the JA Ranch, east of Amarillo. Founded in 1876, the JA is one of 730,000 “cow-calf” operations in the U.S. Calves are typically born in late winter and early spring, graze with their mothers until fall, then overwinter on forage. Though most end up in a feedlot for fattening, they spend more than half their lives grazing, often on land that can’t be used for crops.





At the Ill Forks steak house in Dallas, a restaurant that says it “has re-created the grandiose lifestyle experienced by Texans,” Mother’s Day dinner for the Cade and Deaton families begins with a blessing. For all those gathered, except two young shrimp-eaters, the meal features steak. In some circles these days beef is almost considered poison; in others it’s a taste and a tradition there’s no earthly reason to give up.

the perfect place for feedlots. Besides abundant cattle, it had a warm, dry climate that allowed them to grow fast—they waste energy in cold and mud—and plenty of grain.

Over the next few decades the panhandle became the feedlot capital of the world. Engler started Cactus Feeders in 1975 and built it into the world's largest cattle-feeding company. (It's now the second largest.) The way Engler saw it, his company's mission was to make beef cheap enough for all. "My father didn't know anyone who didn't like the taste of beef," says Mike Engler, the current CEO. "But he knew people who couldn't afford it."

From the beginning, though, the business faced headwinds: In 1976 per capita beef consumption peaked in the United States at 91.5 pounds a year. It has since fallen more than 40 percent. Last year Americans ate on average 54 pounds of beef each, about the same amount as a century ago. Instead we eat twice as much chicken as we did in 1976 and nearly six times as much as a century ago. It's cheaper and supposedly better for our hearts. We slaughter more than eight billion chickens a year now in the U.S., compared with some 33 million cattle.

A friendly, unassuming man of 63, Mike Engler is an unlikely cattle baron. When his father was starting Cactus, Mike was at Johns Hopkins University getting a Ph.D. in biochemistry. He went on to do research at Harvard and the University of Texas. After 24 years away, he came back to Amarillo in 1993—a traumatic year for the beef industry. Four children died and hundreds of people were sickened by hamburgers at Jack in the Box restaurants that had been contaminated by a virulent strain of *E. coli*.

After that came the mad-cow scare; no one yet has gotten the human variant of the brain-wasting disease from American beef, but Americans learned that livestock protein, which can spread the disease if contaminated, had often been fed to cattle until the Food and Drug Administration banned the practice in 1997. In the media a consensus began to form about feed yards: They were cruel, disgusting, and unnatural hellholes, like 14th-century London, Michael Pollan wrote in *The Omnivore's Dilemma,* "teeming and filthy and stinking, with open sewers, unpaved roads, and choking air rendered visible by dust." Only massive use of antibiotics kept the plagues at bay.

In the truck one day I asked Defoor about zilpaterol, a controversial feed additive that makes cattle gain extra weight. He began his answer by asking me to "assume that Mike Engler and Paul Defoor are not evil people." It sounded odd—but it was a reflection of the great disconnect that exists in America between the people who consume meat and the people who produce most of it.

DEFOOR IS A TALL, SLENDER MAN OF 40, with a weathered face and a taste for explaining recondite things like ruminant nutrition—he has a Ph.D. in the subject from Texas Tech. Riding around the panhandle in his pickup, I got to know him a bit. We visited the 320 acres he owns outside Canyon, where he goes after work to plow his wheat field or feed his own small herd of cows and calves. We talked about macroeconomics and the role of government. We even talked about God once or twice. It concerned Defoor that I was on distant terms with Him. It concerned me that Defoor, a deeply scientific man, wasn't much bothered about climate change. We agreed to keep our minds open.

Defoor was raised on a small farm north of Houston, where his family grew all their own food and sold some as well. "We had cows, we had chickens, we had goats," he says. It seems to him now that he was always picking peas; they had a few acres of them. He doesn't miss that life.

It's not how you feed the world, he says. It's not how you increase people's standard of living, starting with the 500 people who work for Cactus. You do those things by using technology to increase productivity and decrease waste.

Forty-nine people work full-time at Wrangler Feedyard, says Walt Garrison, the manager. It takes just seven to operate the automated

The magazine thanks The Rockefeller Foundation and members of the National Geographic Society for their generous support of this series of articles.

mill that cooks three meals a day for 43,000 cattle—750 tons of feed. Next to the computer screens that track the flow of corn from hard kernels at one end of the mill to steam-flaked feed at the other, a sign displays the "Cactus Creed: Efficient Conversion of Feed Energy Into the Maximum Production of Beef at the Lowest Possible Cost." Living that creed requires the technology-assisted coddling of 43,000 rumens.

The rumen is the largest of a cow's four stomachs—"a wonder of nature," says Defoor. It's a giant beige balloon swollen with up to 40 gallons of liquid. The first time I saw a rumen, in a small slaughterhouse in Wisconsin, it filled a wheelbarrow; in life it fills most of the left side of a cow. It's a giant vat in which the food ingested by a cow is fermented by a complex ecosystem of microbes, releasing volatile fatty acids from which the cow gets its energy. At Wrangler, I came to understand, a rumen is also like a high-performance race-car engine, cared for at frequent intervals by a highly trained pit crew.

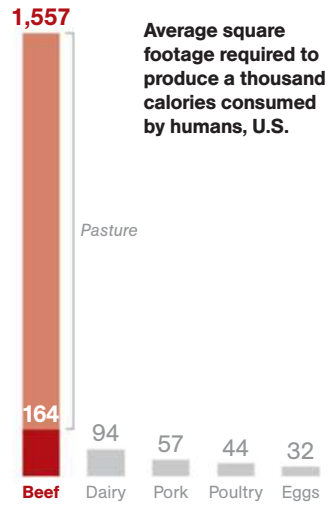
The goal is to pump as much energy as possible through the rumen so that the animal gains weight as fast as possible without making it sick. Ruminants can digest grass, which is mostly roughage. But corn kernels, which are mostly starch, contain much more energy. At Wrangler only about 8 percent of the finishing ration is roughage—ground sorghum and corn plants. The rest is corn, flaked to make the starch more digestible, and ethanol by-products.

The feed also is treated with two antibiotics. Monensin kills off fiber-fermenting bacteria in the rumen that are less efficient at digesting corn, allowing others to proliferate. Tylosin helps prevent liver abscesses, an affliction that cattle on high-energy diets are more prone to.

The high-grain diet also increases the risk of acidosis: Acids accumulate in the rumen and spread to the bloodstream, making the animal sick and in severe cases even lame. Every animal differs in its susceptibility. "That's something we struggle with in this industry," says Kendall Karr, the nutritionist who oversees the diet at all Cactus Feeders yards. "There's so much variation. We're not producing widgets."

THE FOOTPRINT OF MEAT

Land



Beef cattle production accounts for almost **90 percent** of the land used for raising livestock in the United States, acreage that includes pasture as well as cropland for growing feed.

GPS-guided feed trucks deliver precise amounts to each pen, and every morning feed manager Armando Vargas adjusts those rations by as little as a few ounces a head, trying to make sure the animals eat their fill without waste or illness. Cowboys ride through each pen, looking for an indented left flank that suggests a rumen isn't full or a drooping head that signals a sick animal. About 6.5 percent of the feedlot cattle get sick at some point, says Cactus veterinarian Carter King, mostly with respiratory infections. About one percent die before they reach butchering weight, generally between 1,200 and 1,400 pounds.

Pharmaceuticals are crucial to the feedlot industry. Every animal that arrives at Wrangler receives implants of two steroid hormones that add muscle: estradiol, a form of estrogen, and trenbolone acetate, a synthetic hormone. Defoor says these drugs save about a hundred dollars' worth of feed per animal—a significant

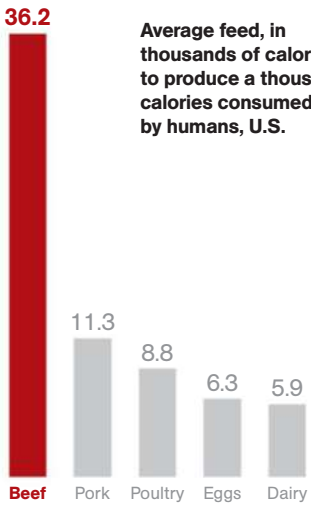
ALL CHARTS: NGM STAFF. SOURCES: GIDON ESHEL, BARD COLLEGE; ALON SHEPON AND RON MILO, WEIZMANN INSTITUTE OF SCIENCE; TAMAR MAKOV, YALE SCHOOL OF FORESTRY AND ENVIRONMENTAL STUDIES, *PNAS*, JULY 21, 2014



On the kill floor at Edes Custom Meats in Amarillo, Justin Hatch reaches for a hook to suspend a cow that's just been killed and skinned. Next he'll cut it in half with a power saw. The sides are "dry aged" for 21 days in a cooler (right) to concentrate the flavor. Small meat-packers like Edes were once common, but today 82 percent of U.S. beef passes through plants that process thousands of cattle a day and are owned by just four corporations. Behind Hatch, the head of the cow awaits the USDA inspector, who'll check the glands and carcass for signs of disease. Every cow slaughtered commercially in the U.S. is inspected.



Feed



The amount of feed needed to produce a thousand calories of consumed beef is more than **three times** that needed for pork. Cattle feed includes pasture, grains, and roughage such as hay.

sum, given the industry's traditionally low profit margins. Finally, during the last three weeks of their lives, the Wrangler cattle are given a beta-agonist. Zilpaterol, the one with the biggest effect, causes them to pack on an extra 30 pounds of lean meat. To the industry, it's an FDA-approved wonder drug—Cactus has given zilpaterol to six million cattle without incident, Defoor says. But last year, after 17 cattle turned up lame at a Tyson Foods slaughterhouse in Washington State, Tyson and other beef packers began refusing cattle that had received zilpaterol. Cactus is now using a beta-agonist that's less potent.

In 2013 the U.S. produced almost the same amount of beef as it did in 1976, about 13 million tons. It achieved this while slaughtering 10 million fewer cattle, from a herd that was almost 40 million head smaller. The average slaughter animal packs 23 percent more meat these days than in 1976. To the people at Cactus Feeders, that's a technological success story—one that meat producers will need to expand on as global demand for meat keeps rising.

"One thing I know is, we're humans, and they're animals," Defoor says. "We have domesticated them for our purpose. We'll treat them with dignity and with respect, but to bring them into a feed yard for 120 or 150 days, that's not a bad environment for them."

WHEN I TELL FRIENDS I SPENT A WEEK on a cattle feedlot, they say, "That must have been awful." It wasn't. The people at Wrangler appeared competent and devoted to their work. They tried to handle cattle gently. The pens were crowded but not jammed—the cattle had around 150 to 200 square feet each, and since they tend to bunch up anyway, there was open space. I spent hours riding around the lot with the windows open and standing in pens, and the smell wasn't bad. After reading Pollan, I had expected to be standing "hock deep" in muddy excrement. I was relieved to be standing on dry dirt—manure, to be sure, but dry. Most cattle feedlots are in dry places like the Texas Panhandle.

Are feedlots sustainable? The question has too many facets for there to be an easy answer. With antibiotic resistance in humans a growing concern, the FDA has adopted voluntary guidelines to limit antimicrobial drug use in animal-feeding operations—but those guidelines won't affect Wrangler much, because the antibiotics there are either not used in humans (monensin) or can be prescribed by a veterinarian to prevent disease (tylosin). The hormones and beta-agonists used at Wrangler are not considered, by the FDA at least, to be a human health concern. But as the animals excrete them, the effect they might have on the environment is less clear.

The issue that concerns Defoor most is water. The panhandle farmers who supply corn and other crops to the feedlots are draining the Ogallala aquifer; at the current pace it could be exhausted in this century. But Texas feedlots long ago outgrew the local grain supply. Much of the corn now comes by train from the corn belt.

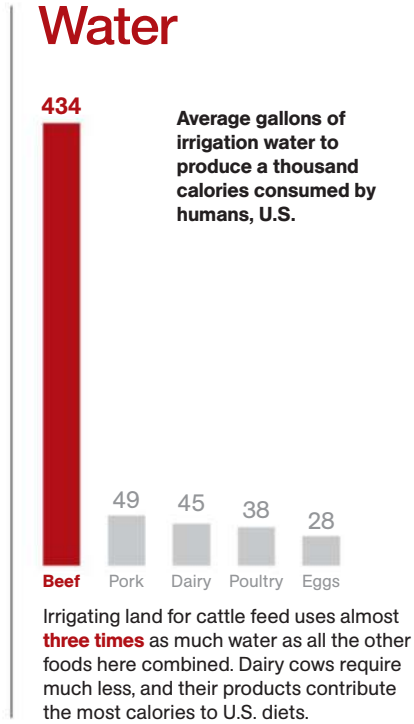
The biggest, most mind-numbing issue of all is the global one: How do we meet demand for

meat while protecting biodiversity and fighting climate change? A common argument these days is that people in developed countries need to eat less meat in general, eat chicken instead of beef, and, if they must eat beef, make it grass fed. I've come to doubt that the solution is that simple.

For starters, that advice neglects animal welfare. After my week at Wrangler, I visited a modern broiler farm in Maryland, on the Delmarva Peninsula, a region that raised 565 million chickens last year. The farm was clean, and the owners seemed well-intentioned. But the floor of the dimly lit, 500-foot-long shed—one of six at the farm—was solidly carpeted with 39,000 white birds that had been bred to grow fat-breasted and mature in under seven weeks. If your goal as a meat-eater is to minimize total animal suffering, you're better off eating beef.

But would Americans help feed the world if they ate less beef? The argument that it's wasteful to feed grain to animals, especially cattle—which pound for pound require four times as much of it as chickens—has been around at least since *Diet for a Small Planet* was published in 1971. The portion of the U.S. grain harvest consumed by all animals, 81 percent then, has plummeted to 42 percent today, as yields have soared and more grain has been converted to ethanol. Ethanol now consumes 36 percent of the available grain, beef cattle only about 10 percent. Still, you might think that if Americans ate less beef, more grain would become available for hungry people in poor countries.

There's little evidence that would happen in the world we actually live in. Using an economic model of the world food system, researchers at the International Food Policy Research Institute (IFPRI) in Washington, D.C., have projected what would happen if the entire developed world were to cut its consumption of all meat by half—a radical change. "The impact on food security in developing countries is minimal," says Mark Rosegrant of IFPRI. Prices for corn and sorghum drop, which helps a bit in Africa, but globally the key food grains are wheat and rice. If Americans eat less beef, corn farmers in Iowa won't export wheat and rice to Africa and Asia.



The notion that curbing U.S. beef eating might have a big impact on global warming is similarly suspect. A study last year by the UN Food and Agriculture Organization (FAO) concluded that beef production accounts for 6 percent of global greenhouse gas emissions. But if the world abstained entirely from beef, emissions would drop by less than 6 percent, because more than a third of them come from the fertilizer and fossil fuels used in raising and shipping feed grain. Those farmers would continue to farm—after all, there's a hungry world to feed.

If Americans eliminated beef cattle entirely from the landscape, we could be confident of cutting emissions by about 2 percent—the amount that beef cattle emit directly by belching methane and dropping manure that gives off methane and nitrous oxide. We made that kind of emissions cut once before, in a regrettable way. According to an estimate by A. N. Hristov of Penn State, the 50 million bison that roamed





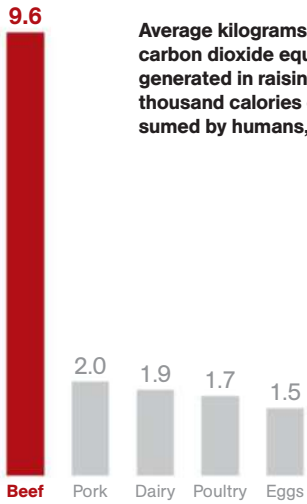
Audrey Bushway and Steven Boyles, visiting from Arizona, got in line at 8 a.m. at Franklin Barbecue in Austin, Texas, where the brisket sells out every day. They ate at noon. “It was amazing,” says Boyles. In America intensive livestock operations produce plentiful meat. Though Americans have reduced the amount of beef they eat, they’ve replaced it mainly with chicken. Global demand for all meat is rising.



An English painting of a well-fed Hereford hangs in the home of Ninia Ritchie, owner of the JA Ranch, which her great-grandfather founded in 1876. Back then, cattle from Texas were often shipped to the corn belt for fattening on small lots. Today midwestern corn is shipped by rail to Texas Panhandle feedlots like Wrangler Feedyard (right), where up to 50,000 cattle are finished on grain for four to six months. Corn is also grown here; to irrigate cornfields, farmers are draining the Ogallala aquifer. Manure stockpiled at Wrangler is delivered to farmers for fertilizer; runoff from the cattle pens collects in a pond and evaporates. The feedlot industry is crucial to the region's economy. "We don't smell odor," says Texas A&M economist Steve Amosson. "We smell money."



Emissions



Greenhouse gases from cattle production are **40 percent** methane, burped by cattle from their specialized stomachs. Cattle fed only grass belch more than those eating grass and feed.

North America before settlers arrived emitted more methane than beef cattle do today.

The problem of global warming is overwhelmingly one of replacing fossil fuels with clean energy sources—but it's certainly true that you can reduce your own carbon footprint by eating less beef. If that's your goal, though, you should probably avoid grass-fed beef (or bison). Cattle belch at least twice as much methane on grass-based diets as they do on grain, says animal nutritionist Andy Cole, who has put them in respiration chambers at the USDA Agricultural Research Service lab in Bushland, Texas. The animals gain weight slower on grass, because it's higher in fiber and less digestible, and for the same reason they emit more methane—wasting carbon instead of converting it to meat. If we were to close all the feedlots and finish all cattle on pasture, we'd need more land and a much larger cattle herd, emitting a lot more methane per animal, to meet the demand for beef.

Here's the inconvenient truth: Feedlots, with their troubling use of pharmaceuticals, save land and lower greenhouse gas emissions. Latin American beef, according to the FAO, produces more than twice as many emissions per pound as its North American counterpart—because more of the cattle are on pasture, and because ranchers have been cutting down so much rain forest to make pastures and cropland for feed. Faced with the staggering problem of meeting rising global demand for meat, "feedlots are better than grass fed, no question," says Jason Clay, a food expert at WWF. "We have got to intensify. We've got to produce more with less."

EVEN PROPONENTS ACKNOWLEDGE that grass-fed beef can't meet the U.S. demand, let alone a growing global demand. "Can't be done," says Mack Graves, former CEO of Panorama Meats, which supplies Whole Foods Market in the West. "Demand is going to keep going up. It's going to have to be beef raised as efficiently as possible, and grass fed isn't efficient compared with feedlot."

Economic efficiency isn't the only criterion, though, Graves says. Cattle graze a lot of land in the world that isn't suitable for growing crops. If the grazing is managed well, it can enrich the soil and make the land more productive—doing what bison once did for the prairie. In New Mexico and Colorado, I visited several grass-fed-beef producers who practice what's sometimes called management-intensive grazing. Instead of letting cattle fan out over a huge pasture for the whole year, these ranchers keep them in a tight herd with the help of portable electric fences, moving the fences every few days to make sure the grasses are cropped just enough and have time to recover.

The guru of the movement is a Zimbabwean scientist named Allan Savory, who says that managed grazing can draw huge amounts of carbon dioxide out of the atmosphere—a controversial claim. But the ranchers I met all swore that managed grazing had transformed their pastures. The beef they're producing is less economically efficient than feedlot beef, but in some ways it's better ecologically. They aren't using

pharmaceuticals in feed. They aren't extracting nutrients in the form of corn from heavily fertilized soil in Iowa, shipping them up to a thousand miles on 110-car trains, and piling them up as manure in Texas. Instead their cattle are building and maintaining a landscape.

At the Blue Range Ranch in the San Luis Valley of southern Colorado, which sells cattle to Panorama, it was calving season when I visited. Like other ranchers in the region, George Whitten and his wife, Julie Sullivan, have struggled to make ends meet during a decade-long drought. But lately there's been a hopeful development: They've partnered with nearby farmers who let them graze their cattle on stubble and irrigated cover crops—sorghum, kale, clover. That fattens the cattle and fertilizes the fields at the same time.

At 5:30 one morning Whitten and I went out into his home pasture to check the cattle. Venus shone like the beam of a helicopter in the eastern sky, above a faint stripe of gray that outlined the snowcapped Sangre de Cristos. After dawn we watched a newborn calf struggle to its feet for the first time. Staggering around its mother on wobbly legs, the little calf finally found the udder.

"They have a great life," Graves says. "And one bad day."

AT WRANGLER I ASKED the veterinarian, Carter King, how it felt to ship cattle he had watched over. "I tell you what," he said, "every time I drive down the interstate and pass a truck that has a load of fats in it, I silently say thank you—thank you to the cattle for feeding our country."

That Tuesday morning, headed north on I-27, Paul Defoor and I caught up with the truck we'd been chasing, which was doing 70 miles an hour. Tyson had not granted my request to visit the packing plant, but Defoor had offered to follow the cattle to the plant gate. He pulled alongside so we could see the cattle, then fell in behind the truck. A fine mist formed on our windshield: A heifer in the truck ahead was relieving herself through the slatted sides.

At the Caviness Beef Packers plant in Hereford, Texas, which slaughters as many as 1,800 cattle a day, the president, Trevor Caviness, gave me a tour. In the "knock box" we watched some cattle die. They were first knocked unconscious by a blow to the forehead from a bolt gun, then strung up by their back hooves and killed by a man with a knife who slit the carotid and jugular. The belief that it's morally wrong to eat animals is appealing, and maybe as a species we'll get there one day, but it's hard to square with our evolutionary history as hunters. The deaths I saw at Caviness and at another slaughterhouse I visited seemed quicker and less filled with terror and pain than many deaths administered by hunters must be.

When I got back from my travels, it was time for my annual physical. My cholesterol was a little higher, and my doctor asked why that might be. I'd been hanging around cattlemen and their steaks, I said. My doctor, who hasn't eaten a steak in 20 years, was unsympathetic. "Just say no," he said. There's no doubt that eating less beef wouldn't hurt me or most Americans. But the science is unclear on just how much it would help us—or the planet.

What my reporting had really left me wanting to say no to was antibeef zealotry. That, and the immoderate penchant we Americans have for reducing complex social problems—diet, public health, climate change, food security—to morality tales populated by heroes and villains. On the Fourth of July weekend I went to the meat counter at my local grocery. There were Angus rib eyes for $10.99 a pound. Next to them, for $21.99, were some grass-fed rib eyes from a ranch in Minnesota. Either would have been OK. But I bought hamburger instead. ☐

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Better Beef Through Genetics

Cattlemen have always paid close attention to their breeds. Can high-tech genetic techniques and cloning help build a cow that's better tasting—and more sustainable?





When Zack Huggins (with the camera) moved in with Leanne Doore (yellow shorts) in Denton, Texas, they invited some friends to gather around their new grill to celebrate. On the menu: hamburgers. "We had a few portobello mushrooms for the vegetarians," Huggins says. He and Doore eat beef only every week or two; chicken is cheaper. "But sometimes I really want a hamburger," Huggins says. "They are really delicious."

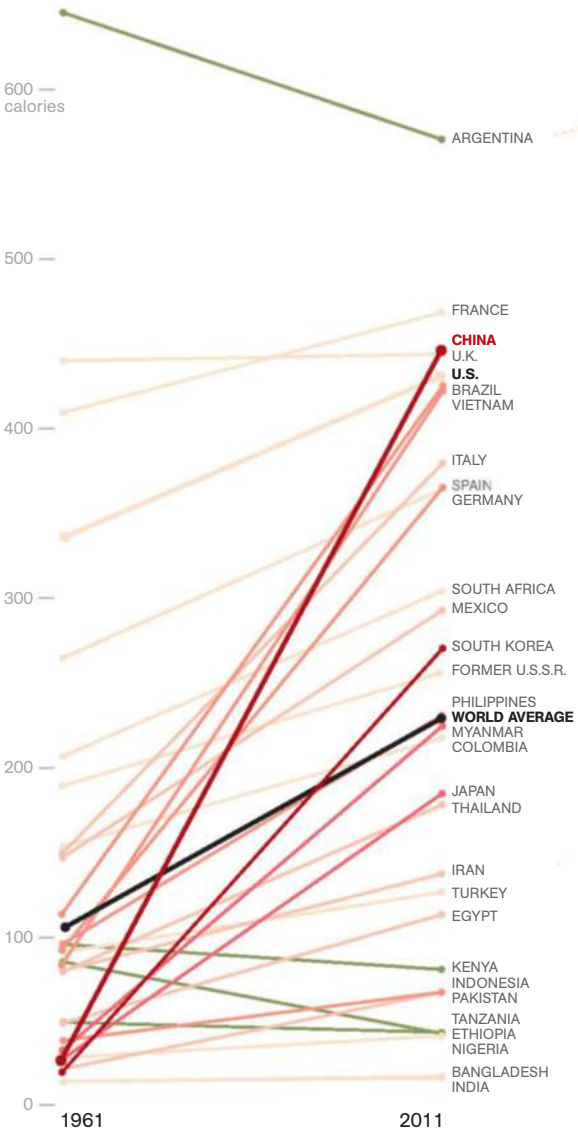


FOOD

Rising Demand for Meat

Appetite for meat is growing as the developing world becomes more prosperous. But meat—especially beef—can be polarizing, on health, environmental, and ethical grounds. Chicken outpaced beef in the U.S. in 2010. Total U.S. meat consumption peaked in the mid-2000s and has declined ever since. Argentina's famous appetite for beef has fallen because of cholesterol consciousness and economic downturns. In countries where meat is a newly affordable option, animal protein is a boon, not a debate. But by 2050, when the world's population is expected to surpass nine billion, crop production will need to double to provide feed for livestock as well as direct human consumption.

Change in calories from meat *per capita per day*

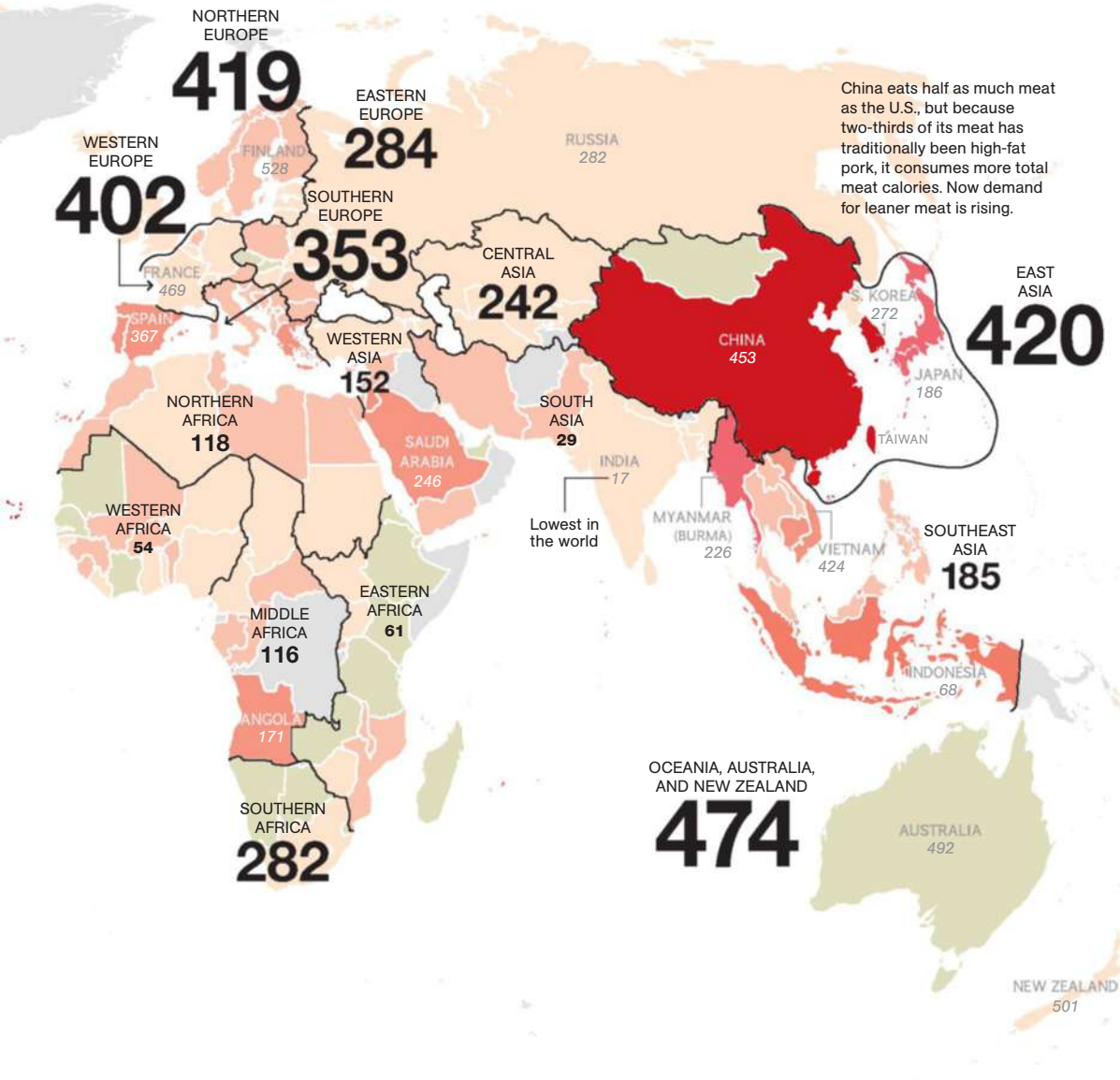




Only countries with populations greater than 40 million shown

Meat consumption
in calories, per capita per day

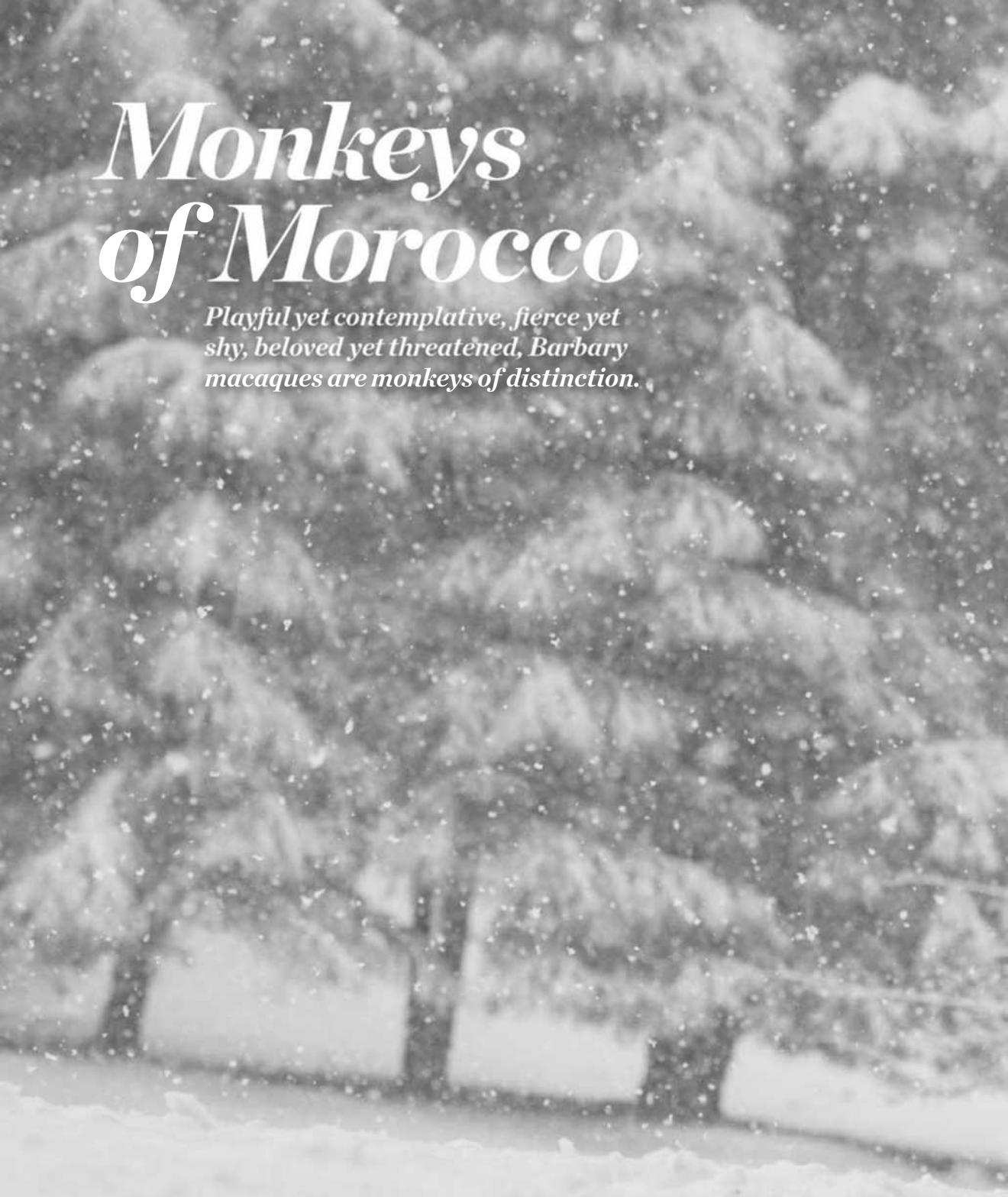
Meat products include cow, buffalo, pig, poultry, sheep, goat, horse, ass, mule, camel, rabbit, game, and aquatic mammals.



PRESENT-DAY BOUNDARIES SHOWN
VIRGINIA W. MASON, JASON TREAT, AND ALEXANDER STEGMAIER, NGM STAFF. SOURCES: FAO

Monkeys of Morocco

Playful yet contemplative, fierce yet shy, beloved yet threatened, Barbary macaques are monkeys of distinction.



Snow clings to a macaque in the Middle Atlas mountains. Barbary macaques are the only African monkeys that live north of the Sahara, and they're one of the few monkey species to dwell in a cold climate.





Photographs by Francisco Mingorance

The Barbary macaque is a monkey of many distinctions. It is the only primate, other than humans, north of the Sahara on the African continent, and it's the only macaque living outside of Asia. Other macaque species once ranged from East Asia to northwest Africa; only the Barbary macaque weathered ecological changes to hold on in Africa.

But it's not just geography that makes this monkey stand out. With thick ginger fur and intelligent eyes, the toddler-size, tailless macaques have long been coveted—and captured—by passing travelers. Skeletal remains of macaques have been discovered in the ashes of Pompeii, deep within an ancient Egyptian catacomb, and buried beneath an Irish hilltop where the Bronze Age kings of Ulster once held court.

These days the Barbary macaque's range has dwindled to pockets of forest in Morocco and Algeria, with a semiwild population in Gibraltar. Unfortunately macaques still tempt visitors. Conservationists estimate that smugglers take some 300 infants out of Morocco each year for the growing European pet trade—crippling the population's sustainability. As few as 6,000 of the endangered monkeys remain—with between 4,000 and 5,000 in Morocco.

Photographer Francisco Mingorance spent more than a year taking pictures of *Macaca sylvanus* high in the Middle Atlas mountains, home to one of the largest Barbary macaque populations. "The love with which they treat their young is almost human," he says. "One mother held her dead child in her arms for four days. This affected me deeply."

Unlike most primates, Barbary macaque males often tote babies around, says Bonaventura Majolo, founder of the Barbary Macaque Project, an ongoing study of the species that began in 2008. They use the infants to establish friendly relations with other males. Majolo calls it a "sandwich interaction." A male will set an infant between himself and another male, and the adults will sometimes groom each other and also attend to the baby.



Males brave many dangers to protect the young. "Some macaques are really scared of people," says Siân Waters of Barbary Macaque Awareness & Conservation. But when she and her colleagues return a lost or stolen baby, "the males come within a few meters. They are so stimulated by the sight of an infant that they lose all fear." *—Rachel Hartigan Shea*

Mingorance calls this young macaque "The Thinker": "He studied me, surprised."







A maple tree provides a perfect swing for a playful macaque. Illegal logging threatens forests where the endangered monkeys live, and overgrazing damages the area's food-rich underbrush.





Above, a big yawn reveals sharp teeth—but these macaques rarely use them in fights. “No one wants to get in a situation where someone gets hurt,” says conservation zoologist Siân Waters. At left, an infant huddles with its mother and older sibling. Although the trade in Barbary macaques is against the law, poachers capture babies to sell in Europe and vendors display them in local markets, where tourists can’t resist a macaque photo op.

Sounds Like Romance

Brilliant, iridescent plumage is evolution's way of helping peacocks lure the ladies. But when there are no peahens in sight, a peacock may draw them with a distinctive sound: a hoot that says he's copulating, even though he isn't.

Researcher Roslyn Dakin spent four years studying how peahens choose a mate. On the lek, or courtship arena, where peacocks strut their stuff, most females choose sex with the same few males whose tail colors and eyespots make them most attractive, Dakin says. At the moment of rapture, males emit a one-of-a-kind hoot—so Dakin was surprised to hear some males make that sound with no females present. Then some peahens came to the lek, and Dakin realized they "might use that sound as a guide" to where the comeliest males are.

To test her theory, Dakin recorded real and fake copulation hoots and played the recordings on the lek—and peahens again showed up. Lacking more research, Dakin can't say whether the males she calls "fake hooters" know that the sound summons possible paramours. What she can say is this: "It's not a surefire way to get a female to come over, but it works better than nothing." *—Patricia Edmonds*

HABITAT
Native to India and Sri Lanka

STATUS
Not threatened

FASCINATING FACT
Courting peacocks shake their tail feathers at a rate of 25 vibrations per second.

Females "might use that sound as a guide" to where the comeliest males are.



This Indian blue peacock, *Pavo cristatus,* was photographed at the Lincoln (Nebraska) Children's Zoo.

PHOTO: JOEL SARTORE


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